





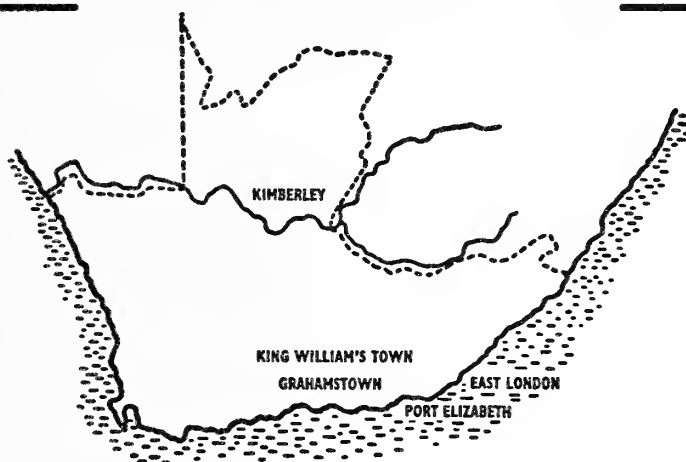




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Notes on the elevation of *Rana fasciata montana* FitzSimons, 1946 to specific rank, and on the identity of *Rana fasciata sensu* Burchell, 1824 (Anura: Ranidae)

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## OPSOMMING

Die Suid-Afrikaanse padda van die Attakwaberge wat in 1946 as *Rana fasciata montana* beskryf is, word hier tot spesifieke rang verhef. Die kenmerkende roep en morfologiese verskille onderskei *Rana montana* **stat. nov.** ongetwyfeld van *Rana fasciata* Smith. Simpatie van die twee spesies by drie lokaliteite ondersteun die verandering van rang van die spesies. Aandag word gevestig op die feit dat die naam *Rana fasciata* Burchell, nou onderdruk, waarskynlik na *Rana fuscigula* Duméril en Bibron verwys en nie na *Rana grayii* soos voorheen voorgestel nie.

## ABSTRACT

The South African frog described from the Attakwa Mountains in 1946 as *Rana fasciata montana* is here raised to specific rank. Distinct call and morphological differences separate *Rana montana* **stat. nov.** unequivocally from *Rana fasciata* Smith. Sympatry of the two species at three localities confirms the species rank separation. It is pointed out that the name *Rana fasciata* Burchell, now suppressed, is probably referable to *Rana fuscigula* Duméril and Bibron and not to *Rana grayii* as previously suggested.

## INTRODUCTION

In 1946, the late V. F. M. FitzSimons described a new subspecies of *Rana fasciata* from the southern Cape Province, South Africa. The types were collected on the "upper slopes" of the Attaqua Mountains and the Langeberge, and the subspecies was accordingly dubbed *Rana fasciata montana*. After examining series of specimens from all over southern Africa, Poynton (1964) assigned most south-west and southern Cape material to this subspecies, thus extending its altitudinal and geographical limits from the mountain slopes of the Jonkersberg to sea-level near Cape Town.

In June 1976 the authors made a joint collecting expedition to Kleinmond near Cape Hangklip, an area of outstanding botanical and zoological interest, with the object of compiling a checklist of local anurans. One of us (J.C.G.) was familiar with the melodious piping call of *Rana fasciata fasciata* from the eastern Cape, and queried the identification by R.C.B. of a lower-pitched creaking call as the same species. When a male "*R. fasciata montana*" emitting this creaking call was eventually tracked down, it was apparent to both of us that eastern and western Cape forms were separable at species level, and that *Rana fasciata montana* would have to be elevated to full specific rank. This paper represents observations on both *Rana fasciata* and *Rana montana* **stat. nov.**

## DIFFERENTIATION BETWEEN *RANA FASCIATA* AND *RANA MONTANA* **STAT. NOV.**

### VOCALISATION

Mating calls in the Anura are generally recognised as being species-specific, their principal function being to guide gravid females to conspecific males (Blair 1958; Pengilley 1971). They are regarded as sensitive taxonomic tools which can be used with confidence in the separation of species, even the morphologically similar forms known as sibling species (Passmore 1977; Passmore and Carruthers 1975).

The calls of the two species under discussion are totally dissimilar. Poynton (1964) describes the call of *Rana fasciata* Smith as a "clear, high-pitched 'pip' . . . a familiar sound near streams on a frosty night." Wager (1965) describes it as a "high-pitched, short, melodious whistle like 'whip', usually single or double and at long intervals, but sometimes repeated rapidly

a number of times, almost like a tinkle.” Stewart (1967) notes that the call of the subspecies *fuelleborni* in Malawi is a “loud, musical ‘put, put, put’, developing into a melodic chorus during the day or night during most of the year . . . The call may be single, or repeated several times as a musical ripple”.

Unlike these authors, Walter Rose was based in the western Cape, the range of *Rana montana*. In his popular account of southern African herpetology (1962), there is evidence of confusion over the calls; he photographically illustrates both “*Rana fasciata montana*” and *R. fasciata fasciata*, and describes the call of the “species” as follows: “The mating call is a high-pitched ‘Wheet, wheet’. At other times it now and again utters a slow ‘Chuck, chuck, chuck’.” The first description is clearly that of the call of *Rana fasciata*; the second is equally certainly of the call of *Rana montana*.

The “chuck, chuck, chuck” could well be used as a verbal description of the call of *Rana montana*. It never develops into the aptly named “musical ripple” of the *R. fasciata* mating chorus. It is medium-pitched, relatively infrequently produced, and could be described as a short explosive creak. Onomatopoeic descriptions of frog calls, however, are notoriously subjective, and a “short explosive creak” to one observer could well be rendered by another as a “staccato belch”. The calls are therefore best graphically represented as oscillograms or sonograms (occasionally spelt “sonagram”) for objective comparison between species.

The oscillograms and sonograms shown below were derived from recordings made in the field on a Uher 4400 Report Stereo 1C portable tape-recorder at a tape speed of 19 cm/s, using an AKG D900 directional microphone. The oscillograms were obtained using a Biomation Model 1015 Waveform Recorder and a Tektronix D12 Oscilloscope. The sonograms were obtained after analysis on a sound spectrograph (Kay model 7029A spectrum analyser). The frequency range was 80–8 000 Hz and a wide band filter (300 Hz) was used.

The mating call of *Rana montana* is illustrated in the oscillograms in Figs 1, 2 and 3. These particular calls were recorded at Kleinmond (3419 AC Hermanus) on 25 July 1978. It can be clearly seen from Figs 1 and 2 that the call consists of a series of closely-grouped pulses. The call durations are respectively 80 ms and 60 ms (although we have found the duration may extend to 120 ms). Fig. 3 displays the detail of the first 2½ pulses of the call shown in Fig. 2.

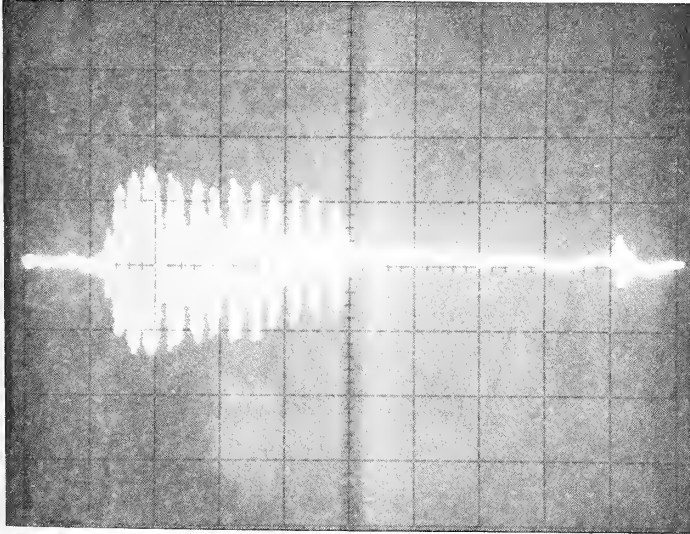


Fig. 1

*Rana montana*  
oscillogram of single mating call  
(whole frame 200 ms)

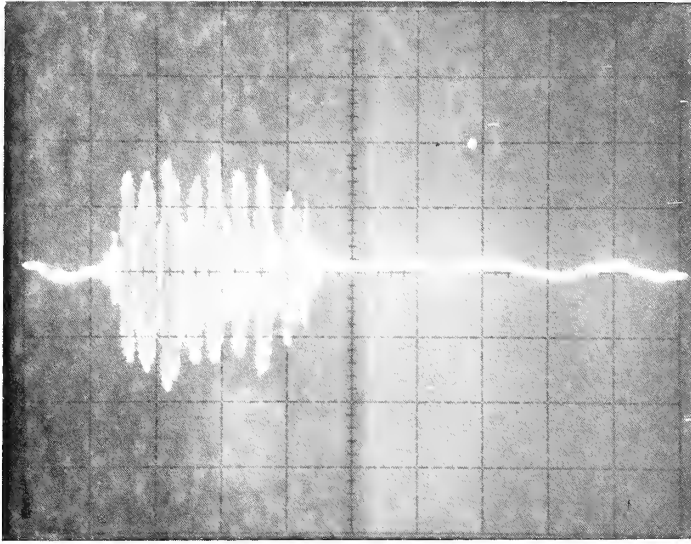


Fig. 2  
*Rana montana*  
oscillogram of single mating call  
(whole frame 200 ms)

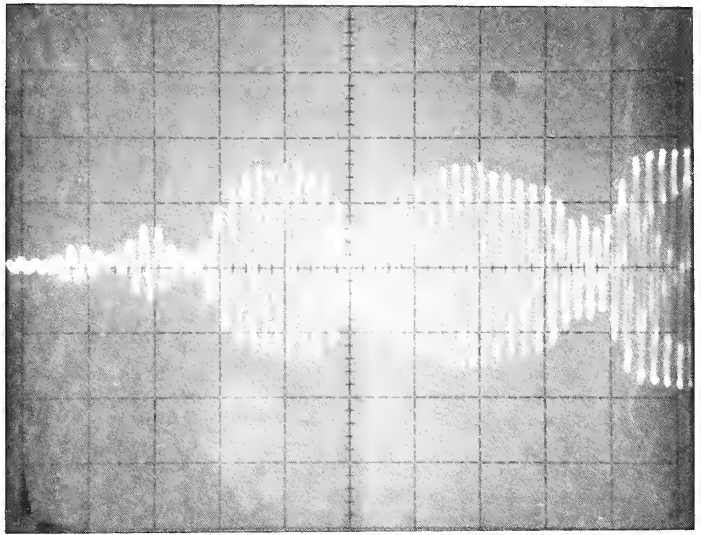


Fig. 3  
*Rana montana*  
enlargement of first 2½ pulses of  
call in Fig. 2 (whole frame 20 ms)

*Rana montana* calls are produced slowly and deliberately, often several seconds separating each. From tape-recordings made at Kleinmond and Jonkersberg, we calculated the minimum call interval at 1,3 seconds, although this would slow down to 3 to 10 seconds between faster bouts of calling. One fast sequence was noted as 1,8; 2,3; 1,9; 1,6; 2,0; 2,0; 1,6; 1,3; 1,4; 1,6 seconds.

*Rana fasciata*, however, produces calls which are almost pure tones with no subdivision into pulses. Fig. 4 shows a portion of a call sequence recorded on 26 July 1978 at Buffeljagsrivier (3420 BA Suurbraak) on the same scale as the *montana* calls in Figs 1 and 2. Call duration here is about 20 ms, the "pip", "put", or "whip" of earlier writers. When this

particular "ripple" of five calls is compressed on to one oscillogram (Fig. 5), it can be seen that the temporal separation of the calls is remarkably uniform, about 80–90 ms between each. A single call expanded to show structural detail is illustrated in Fig. 6; this is directly comparable in scale with Fig. 3 and shows the symmetrical nature of the single call.

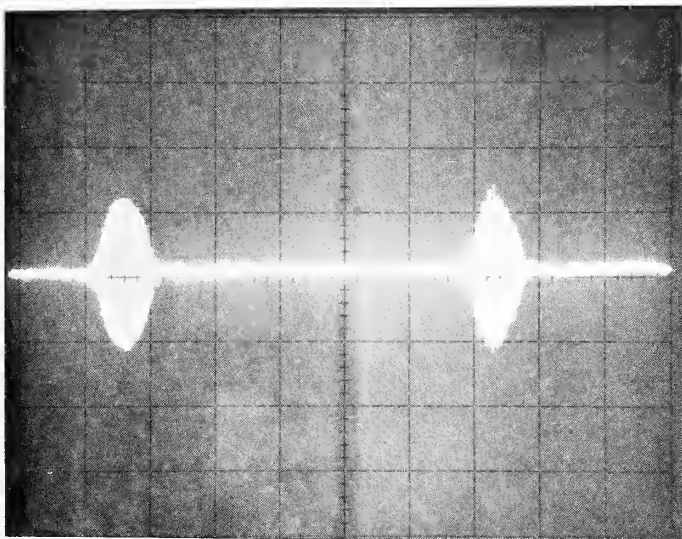


Fig. 4

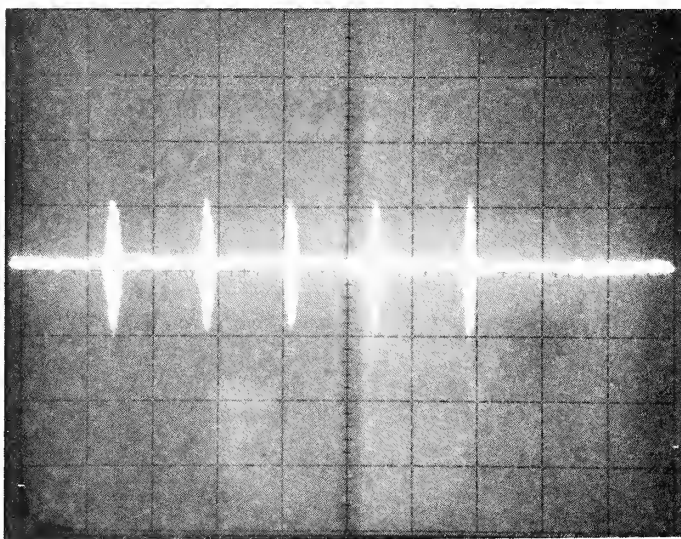
*Rana fasciata*

oscillogram of 2 calls from a "ripple" of 5 calls (whole frame 200 ms)

Fig. 5

*Rana fasciata*

oscillogram of a "ripple" of 5 calls (whole frame 800 ms)



The sonogram of a single call of *Rana montana* is shown in Fig. 7; its duration is 75 ms, and its frequency range is 2,7 kHz–3,25 kHz. This call was also recorded at Kleinmond (3419 AC Hermanus).

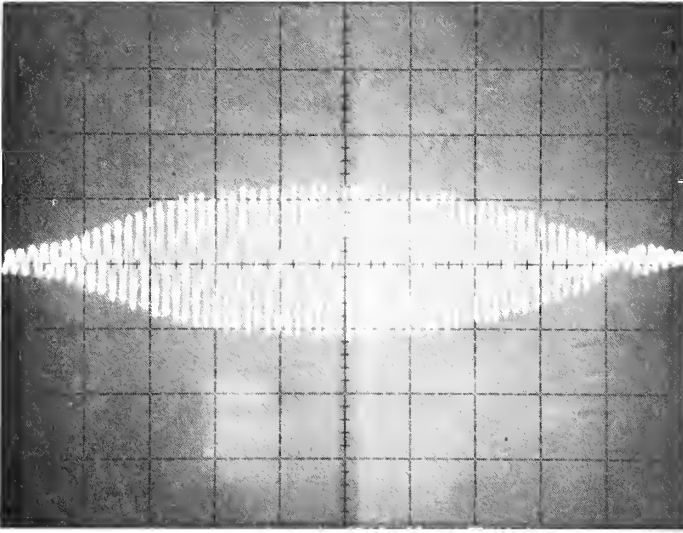


Fig. 6

*Rana fasciata*  
enlargement of one call from "ripple" in Fig. 5 (whole frame 20 ms)

Fig. 8 is a sonogram of two successive calls of *Rana fasciata* from Port Elizabeth (3325 DC Port Elizabeth); these calls are not part of a "ripple" sequence, and consequently have longer durations of 30 ms and 20 ms respectively, with a frequency range of 3,25 kHz–4,0 kHz.

Eight calls from a "ripple" sequence of *R. fasciata* are shown in Fig. 9. They are more staccato than the single calls, lasting only 15–17 ms each, with a slightly contracted frequency range of 3,25 kHz–3,83 kHz. The gaps between the calls of the ripple vary between 90 and 115 ms.

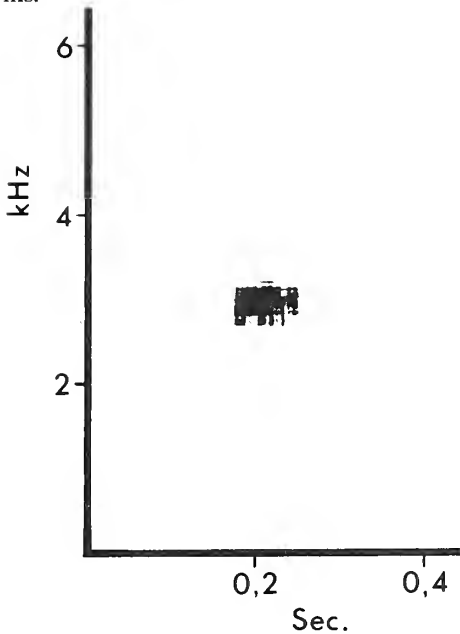


Fig. 7

*Rana montana*  
sonogram of single call using wide-band (300 Hz) filter



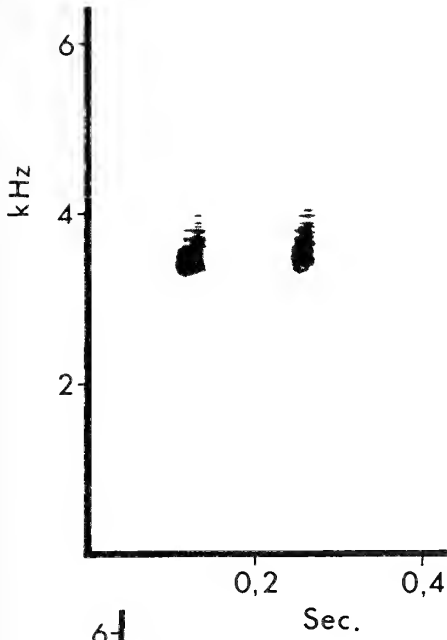


Fig. 8

*Rana fasciata*  
sonogram of 2 successive calls using  
wideband (300 Hz) filter

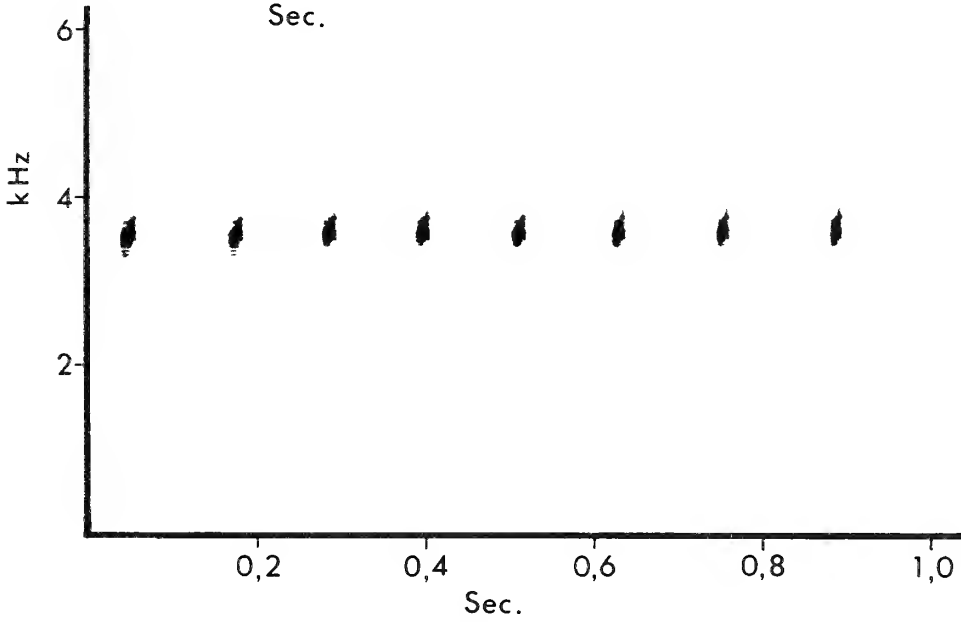


Fig. 9

*Rana fasciata*  
sonogram of 8 calls in a "ripple" using wideband (300 Hz) filter

The calls of the two species are clearly distinctive as shown by both oscillograms and sonograms. *Rana montana* does not produce a rapid succession of calls, the frequency range is lower than in *R. fasciata*, and each call is subdivided into pulses, giving rise to a creaking effect. There can be no question but that the call difference alone can be used to separate the two species.

## MORPHOLOGICAL FEATURES

### General

The main features used by FitzSimons (1946) to distinguish the subspecies *montana* from *fasciata* were:

- (1) the longer, more pointed snout of *montana*
- (2) reduced webbing on feet of *montana*
- (3) proportionately shorter feet of *montana*
- (4) colour markings

We do not consider that the snout can be demonstrated unequivocally to be longer or more pointed, nor that the foot can be shown to be proportionately shorter. We do, however, add two other diagnostic characters to replace those two of FitzSimons.

- (1) proportionately longer first toe of *montana*
- (2) presence of a preorbital caruncle in *montana*

### Length of snout

FitzSimons (*op. cit.*) described the snout of *montana* as "sharply pointed and strongly projecting, its length at least twice diameter of eye (in typical *fasciata*, snout distinctly less than twice diameter of eye)"; he also stated that the snout length is not more than 2,1 times into the distance between snout and vent, as opposed to 2,2 to 2,3 times in *fasciata*.

We do not agree that the snout of *montana* is obviously longer or more sharply pointed. In certain individuals it may be proportionately longer than in typical *R. fasciata* but in such cases extra length is in our view not quantifiable. The length of snout/diameter of eye ratio is not a valid point of difference, and we find it difficult to understand FitzSimons' statement that the snout-vent length/snout length ratio is 2,1 in *montana* and 2,3 in *fasciata*, when this ratio is normally of the order of 5,4 to 6,1, and does not appear to us to present a clear-cut species difference.

### Extent of webbing

FitzSimons stated that the webbing on the feet does not extend as far as the basal subarticular tubercles of the digits, while in *R. fasciata* the webbing extends as far as the basal tubercles. Loveridge (1953), discussing the validity of *R. fasciata fuelleborni*, examined 119 specimens of various races of the species (including an unspecified, but presumably very small number of "*R. fasciata montana*") and asserted that the extent of webbing on the toes was the same in all races, viz. from the first to the fifth, the free phalanges were 2, 2, 3, 4, and 3. Inger (1959) adduced this statement as additional evidence for the rejection of *montana* as a distinct subspecies. Poynton (1964), however, states that in *montana*, four phalanges of the fourth toe are free of web, compared with "3½ to 4" in *R. fasciata*.

In all 80 *Rana montana* specimens examined, we have found that the webbing does not reach the basal subarticular tubercle on the fourth toe; this means in effect that four phalanges of the fourth toe are free of web (Fig. 10a). In *Rana fasciata* the webbing in all specimens examined (from the S. and E. Cape) clearly extends beyond this tubercle, but not, however, as far

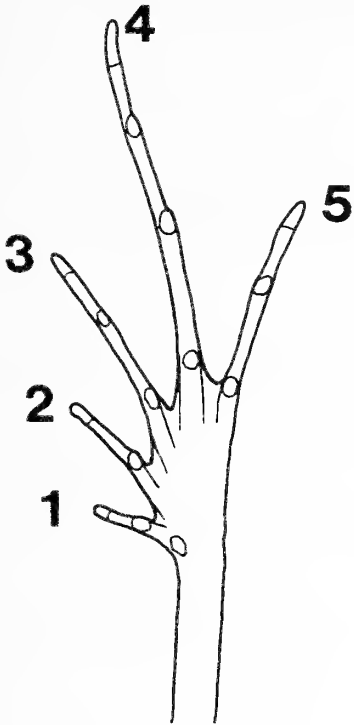


Fig. 10a

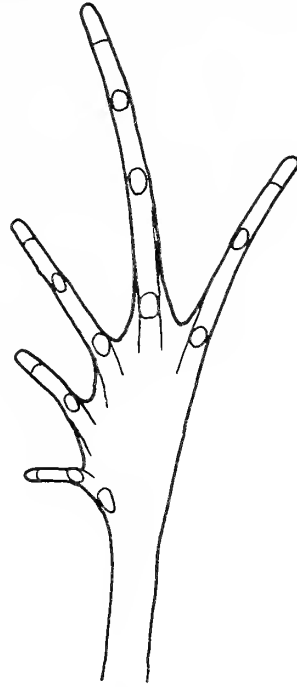


Fig. 10b

Left foot of *R. montana* showing extent of webbing

Left foot of *R. fasciata* showing extent of webbing

as half-way along the phalanx (Fig. 10b), thus perhaps contributing to the confusion concerning the extent of the webbing, which is normally expressed in units of whole or half phalanges. In some specimens the web just reaches the tubercle on the side adjacent to toe 3, but in these cases the web on the side adjacent to toe 5 still extends beyond the tubercle. Reduction in webbing is also apparent at the basal subarticular tubercle of toe 5; in *montana* the web reaches this tubercle, while in *fasciata* it extends beyond it.

Another feature noticeable in *fasciata* but less so in *montana* is the continuation of the web to the tip of each toe in the form of a narrow flange. We define the web as commencing when the edge of the flange ceases to run parallel to the digit.

As FitzSimons (1946) claimed, therefore, there is a slight but significant and consistent reduction in the extent of webbing on the feet of *Rana montana* in comparison with *R. fasciata*.

#### *Length of foot*

Again it is necessary to draw attention to an apparent contradiction in FitzSimons' description. He states that *montana* has a proportionately shorter foot than *fasciata*, but goes on to say that the length of the foot of *montana* goes less than 1.1 times into the snout/vent length, while in *fasciata* it is over 1.1 times. These statements are clearly contradictory.

After measuring a number of specimens of both species, we conclude that there is no marked difference between the species in proportionate length of the feet.

Poynton (1964) compares foot length (distance from the proximal end of the metatarsal tubercle to the tip of the fourth toe) with the urostyle/tympanum or urostyle/eye length. Both *R. fasciata* and *R. montana* are variable in this character, and in both, the length of the foot is equal to the distance from the tip of the urostyle to the anterior margin of the tympanum *or* to the eye (this character may be used to compare these species with *R. grayii* where the foot length is equivalent to the distance between urostyle tip and the axilla, or rarely the *posterior* margin of the tympanum).

#### *Length of first toe*

When the first toe of *Rana montana* is adpressed parallel to the second toe, the tip of the toe normally reaches to the middle of the subarticular tubercle at the base of the second toe, and frequently to the distal end of the tubercle. In our largely eastern and southern Cape sample of *R. fasciata*, the tip of the first toe usually reaches only to the proximal end of the same tubercle, and frequently falls short of it.

#### *Preorbital caruncle*

At the anterior corner of the eye of *Rana montana* is a small fleshy lobe, which is absent in *R. fasciata*. Although the word "caruncle" is perhaps most commonly associated with hard or solid structures, its correct application is to small fleshy excrescences, and we therefore use the term "preorbital caruncle" to describe this character.

In *Rana fasciata*, the skin over the top of the orbit (the upper eyelid) meets the skin of the snout at the anterior corner of the orbit in a fold or shallow groove. The fold presumably caters for expansion and contraction of the skin in movements of the eye (Fig. 11b). There is a small notch in the fold next to the eye itself.

*Rana montana*, on the other hand, possesses two folds about 0.5 mm apart. The skin tissue between the folds appears to be slightly swollen, hence the caruncle effect (Fig. 11a). The upper fold, which is analogous to the single fold of *R. fasciata*, is more deeply incised next to the eye, the incision being overlapped by the caruncle like a flap. The lower fold is also deeply incised but the two sides of the fold are adpressed together and do not overlap. In only one specimen, out of 80 examined, was there any doubt about the presence of the lower fold, but in that specimen the other preorbital caruncle was clearly visible. (The caruncle is also visible in Fig. 12).

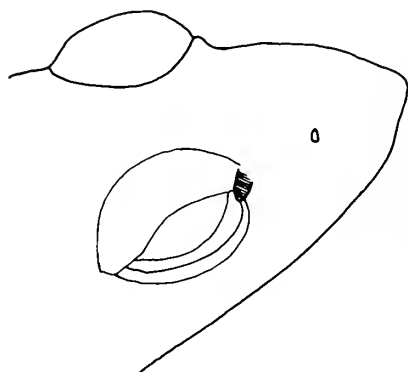


Fig. 11a

Preorbital caruncle of *R. montana*

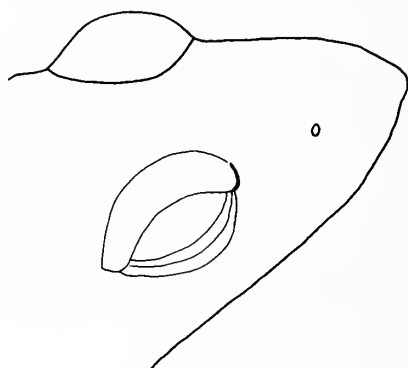


Fig. 11b

Preorbital groove of *R. fasciata*

*Colour markings*

The colour markings of *Rana montana* have been described in some detail by FitzSimons (1946). His description was based, however, on a small sample of six specimens and he did not explain clearly how *montana* differs from *fasciata*. The description which follows is based on 80 specimens, the majority of which were collected by officers of the Cape Department of Nature and Environmental Conservation. The occurrence of colour pattern polymorphism in *R. montana* is here recorded for the first time. The colour markings of the dominant morph are illustrated in Fig. 12.

A mesial vertebral stripe is always present, from behind the nostrils (rarely tip of snout or eyes) to the tip of the urostyle, either one third of the width between the two sacral hump projections, or rarely much broader (as wide as, or wider than the sacral hump), usually silver, yellow or orange-brown but often silver suffused mesially with orange-red. The narrow stripe morph has this stripe bounded by dark brown stripes of the same width, broken for the posterior third of their length, and rarely along their entire length. A silver dorsolateral stripe from the axilla to groin is bounded by shorter dark brown stripes above and below. The dorsal ground colour is usually light brown or olive-grey. Occasionally a rufous stripe may be present between the dark brown vertebral stripe and the upper dark brown dorsolateral stripe above the axilla, but this does not extend as far as the sacral hump. A few raised white spots are scattered over the flanks posteriorly. A rufous spot is occasionally present mesially to the anterior corner of the eye. The upper surface of the upper arm is often tinged with rufous. A dark brown stripe runs from the snout through the eye to the axilla, bounded below by a raised silver stripe which extends from the axilla to a point mid-way between the nostrils and the snout, but often less boldly from the anterior corner of the eye to the nostrils. Occasionally specimens may be encountered with all light-coloured areas on the upper surfaces of the limbs and dorsum suffused irregularly with blood-red pigment.

The belly is immaculate silvery gold. The throat is also immaculate, but in females there is a deepening of the golden colour at the sides, while in males the gular area may be quite suffused with light brown or black especially between the edge of the lower jaw and the longitudinal folds at the sides of the vocal sac, and often between these folds. The latter are distinct and extend from the pectoral region to the anterior edge of the lower jaw. The under surface of each limb is dusky pink or brown. The upper surfaces of both femur and tibia are strongly banded transversely with brown or dark brown, the femur with 4–6 bands, the tibia with 3–6 bands. The main tibial and femoral bands match when the frog is at rest with folded limbs. The tarsus is also banded, the banding extending the length of the fourth toe.

*Rana montana* is separable from *R. fasciata* on the leg banding alone, as pointed out by FitzSimons (1946) and Poynton (1964). *R. fasciata* never possesses tibial cross-bands (Fig. 13).

Markings similar to cross-bands may occur in *fasciata* on the femur (which can, however, possess no recognisable markings at all), but if present, they are attenuated and longitudinally rather than laterally extended. Tibial markings never develop into transverse bands but are always longitudinally oriented and sometimes extend in one stripe almost the whole length of the tibia; such markings are usually weakly developed. The light coloured longitudinal vertebral stripe is usually about half the width between the sacral projections. The throat of *Rana fasciata* is immaculate and also suffused with gold. In males, however, the throat is a rich golden yellow.

Like many anurans, *R. montana* is capable of colour change in response to environmental conditions (although Rose 1962 did not note "any appreciable power of colour change"). The dark phase is in our experience the most frequently encountered, and here the entire dorsal pattern is obscured except for the light vertebral and dorsolateral stripes and spots. Appropriate heat and light treatment can induce change to the light phase within a half-hour.

The existence of colour pattern polymorphism in *Rana montana* is of considerable interest. *R. fasciata* apparently does not vary significantly from the basic pattern as portrayed by Poynton





Fig. 12. Male *R. montana* from Kleinmond (3419 AC Hermanus).

(1964), Wager (1965), Stewart (1967) and Fig. 13, but *R. montana* exhibits two basic pattern morphs. The normal morph is that illustrated in Fig. 12, with a narrow light vertebral stripe, in width approximately one third of the distance between the two projections of the sacral hump. The other is the dorsoconcolor morph (Fig. 14a), so named by Lynch (1966) after a leptodactylid frog from Central America; this pattern variant consists of a broad unicoloured dorsal area, extending from the snout over the eyes, tapering to the tip of the urostyle.

Sixteen of our sample of 80 specimens (i.e. 20%) showed the dorsoconcolor pattern but this figure is slightly biased. One collector of five specimens, three of which were dorsoconcolor morphs, believes that he selected the more attractive frogs out of a total of twenty frogs handled, these probably being dorsoconcolors (Herrington pers. comm.). If this sample is deleted from the total, the relevant proportions are 13 out of 75 (17.3%), and if sight records are added the percentage drops to 15%. Geographical distribution of the dorsoconcolor morph is not clear because of inadequate sampling. However, two came from Betty's Bay (3418 BD), two from Kleinmond (3419 AC), eleven from the Muizenberg Mountains on the Cape Peninsula (3418 AB), and one from the Great Winterhoek Mountains (3319 AA). We have none as yet from the eastern range of the species.



Fig. 13. Male *R. fasciata* from Theescombe, Port Elizabeth (3425 AB Uitenhage).

The same form of polymorphism occurs in *Phrynobatrachus* (Stewart 1974), and in *Rana grayii*, which possesses "no stripe", "thin stripe" and dorsoconcolor morphs. The dorsoconcolor patterns of *R. montana* and *R. grayii* are compared in Figs 14a and 14b. Polymorphic pattern systems obviously play a role in protection from predators, especially in diurnal species; there is some evidence that *Rana montana* is at least partially diurnal (see life history notes).

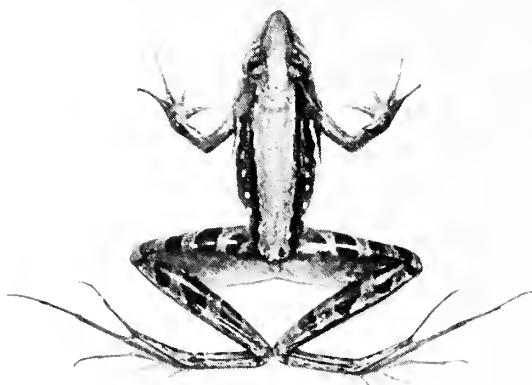
#### *Size and sexual dimorphism*

Poynton (1964) gives snout/vent lengths (of the flattened animal) for *Rana fasciata* as 50 mm, and for *R. montana* as 47,5 mm. There is probably, however, no significant size difference between the two species, as we have examined a large female *R. montana* of length 50 mm from Swartboschkloof, Jonkershoek State Forest (coll. R. A. Haynes; in the Department of Forestry collection).

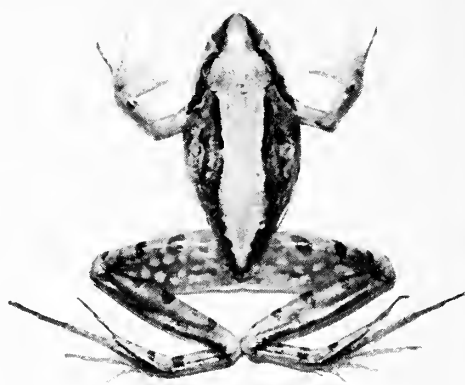
Females of *R. montana* attain a larger size than males, averaging 40–50 mm and 31–40 mm respectively. The males are recognisable when sexually mature by the presence of nuptial pads on the thumbs and the longitudinal fold at each side of the vocal sac, as in *Rana fasciata*.

#### *Morphological separation from R. fasciata and R. grayii*

The three species, *R. montana*, *R. grayii*, and *R. fasciata*, resemble each other in general conformation, are of approximately the same size, live in similar habitats, call in winter and are long-toed jumping frogs with reduced webbing. Identification may therefore present problems,



a. *R. montana* from Muizenberg Mtns. (3418 AB Simonstad/Simonstown).



b. *R. grayii* from Muizenberg Mtns. (3418 AB Simonstad/Simonstown).

Fig. 14. Dorsosconcolor pattern morphs

especially with dorsosconcolor variants of *R. montana* and *R. grayii* which are often sympatric. Guidelines for separating them are provided below, but it should be noted that a hand-lens may be necessary for some characters.

#### *Rana montana*

- (1) possesses preorbital caruncle.
- (2) webbing does not reach the basal subarticular tubercle on the fourth toe, and reaches basal tubercle on the fifth toe.
- (3) tip of first toe normally reaches to middle of basal subarticular tubercle of second toe or beyond.
- (4) femur and tibia distinctly cross-banded, the main bands corresponding when the femur and tibia are adpressed. Even in the case of the dorsosconcolor morph, the cross-bands are distinct and complete (see *R. grayii*).
- (5) length of foot equal to distance from tip of urostyle to anterior margin of tympanum or to the eye. (The length of the foot is taken to be the distance from the proximal end of the metatarsal tubercle to the end of the fourth toe.)

#### *Rana grayii*

- (1) possesses single preorbital groove.
- (2) webbing does not extend beyond the basal subarticular tubercle on the fourth toe, but reaches perceptibly beyond basal tubercle on the fifth toe.
- (3) tip of first toe may fall short of basal subarticular tubercle of second toe or extends beyond it. A variable character in this species.
- (4) femur and tibia usually distinctly cross-banded, the bands corresponding when femur and tibia are adpressed. Femur and tibia in certain individuals (especially in the dorsosconcolor morph) may have cross-bands absent or incomplete, but never longitudinally oriented.
- (5) length of foot equal to distance from tip of urostyle to axilla (very rarely to posterior margin of tympanum).

*Rana fasciata*

- (1) possesses single preorbital groove.
- (2) webbing (at least in E. and W. Cape specimens) reaches beyond basal subarticular tubercle of fourth toe and fifth toe (but only about one quarter way along the phalanx).
- (3) tip of first toe normally barely reaches the basal subarticular tubercle of the second toe, and frequently falls short of it.
- (4) femur and tibia *not* cross-banded. Femur may have attenuated patches of brown corresponding to the cross-bands of the other two species; tibia has no cross-bands, but may have longitudinally oriented streaks.
- (5) length of foot equal to distance from tip of urostyle to anterior margin of tympanum or to the eye.

**DISTRIBUTION**

Distribution localities given in this paper are cited according to the standard system for biogeographical mapping proposed by Greig and Boshoff (in prep.). The grid blocks on the accompanying maps are one quarter degree of latitude by one quarter degree of longitude "square" and each is known as a "locus".

Poynton (1964; Map 34) provides an accurate distribution map for *Rana montana* under the name *Rana fasciata montana*, correctly attributing all western Cape "*fasciata*" material to this form. It may be noted from his map that the "subspecies" *montana* and *fasciata* each overlap the other's range in the southern Cape.

This apparent overlap was one of the reasons why Inger (1959) suggested that *Rana fasciata montana* was a dubious subspecies. In 1950/51, the Lund University Expedition collected four specimens of *Rana fasciata*, from the Bloukrans River east of Plettenberg Bay (3323 DC Nature's Valley), Grootkop, Knysna (3423 AA Knysna), 16 miles north of Matatiele (3028 BB Lehlohonolo), and Barotta, 27 miles east of Louis Trichardt (2330 AB Levubu). In his assessment of this material, none of which of course differed from typical *R. fasciata*, Inger noted that FitzSimons' localities for *montana* were interspersed with those he gave for *fasciata* in the southern Cape Province, and that the supposed preference of *montana* for higher elevations was shared by the Lund Expedition's Matatiele *fasciata* specimen (given as 1905 m).

The localities in question given by FitzSimons were Jonkersberg and Grootvadersbos (= Grootvadersbosch) for *montana*, and Garcia and Still Bay for *fasciata*. If FitzSimons' subspecies had been valid, the existence of a population of *fasciata* at Garcia would be difficult to explain, as this locality lies directly between Grootvadersbos and Jonkersberg, on the same mountain range as Grootvadersbos.

The recognition of *Rana montana* as a species in its own right, however, resolves the problems of altitudinal and geographic overlap. Indeed, the overlap is more complete than Inger had believed; we re-visited each of FitzSimons' southern Cape localities for *Rana montana* and *Rana fasciata*, and while confirming the validity of his collections, we found that in fact *R. montana* and *R. fasciata* exist more or less sympatrically at Grootvadersbos, Garcia and in the Outeniqua Mountains, while clearly maintaining their specific identities. "True" sympatry, in Mayr's (1969) sense of the "existence of a population in breeding condition within the cruising range of individuals of another population", would be difficult to prove and may not exist; nevertheless, at these three localities, calling males of both species could be heard simultaneously by an observer although from different locations and differing habitats. This observation constitutes the final proof, if such were required, of the specific distinction of the two forms.

It was chance which led FitzSimons to collect only *R. montana* at Grootvadersbos and Jonkersberg, and only *R. fasciata* at Garcia; he could so easily have collected both species at each collecting station.

The question of altitude is not significant in itself. The determinant is habitat availability. Further detailed study is of course required, but *R. montana* distribution is apparently tied to the "fynbos" vegetation type. It occurs from mountain top to the sea in the winter rainfall zone of the western Cape, but in the southern Cape, where the climate is transitional to a summer rainfall pattern, it is restricted to the mountains. In the mountains of the eastern Cape Province, and in the Natal Drakensberg, *R. fasciata* finds suitably moist grassy habitat at high altitude, as the Lund University Expedition found, and it extends down to sea-level all along the Natal and Cape coasts as far west as Still Bay; it does not occur in the coastal fynbos of the winter rainfall region of the S.W. Cape.

Figs 15 and 16 show the distribution ranges of *Rana montana* and *Rana fasciata* respectively. They are based on Poynton's map, with one or two corrections together with a number of additional localities from a survey by the Cape Department of Nature and Environmental Conservation from 1972 to 1978. The range of *Rana fasciata* is here shown to extend nearly 110 km further to the south-west than previously recorded (Garcia; see FitzSimons 1946;

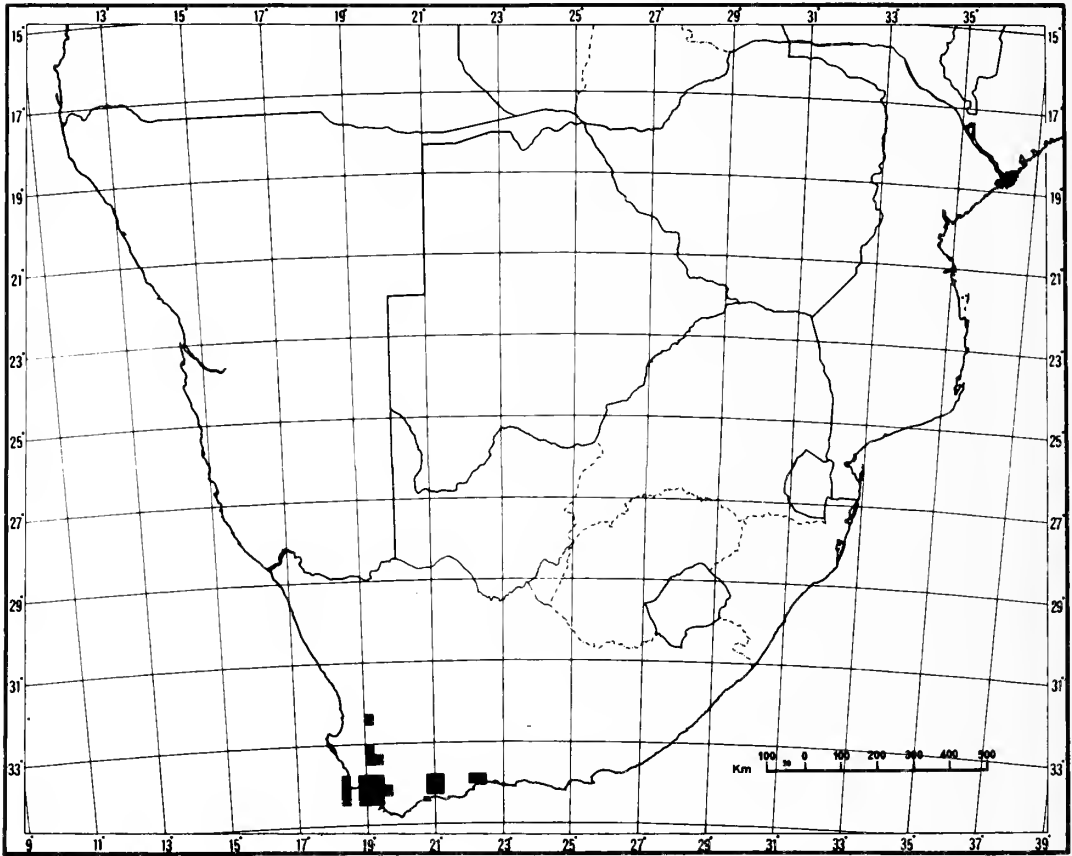


Fig. 15

Distribution of *Rana montana* FitzSimons plotted on the latitude/longitude grid.



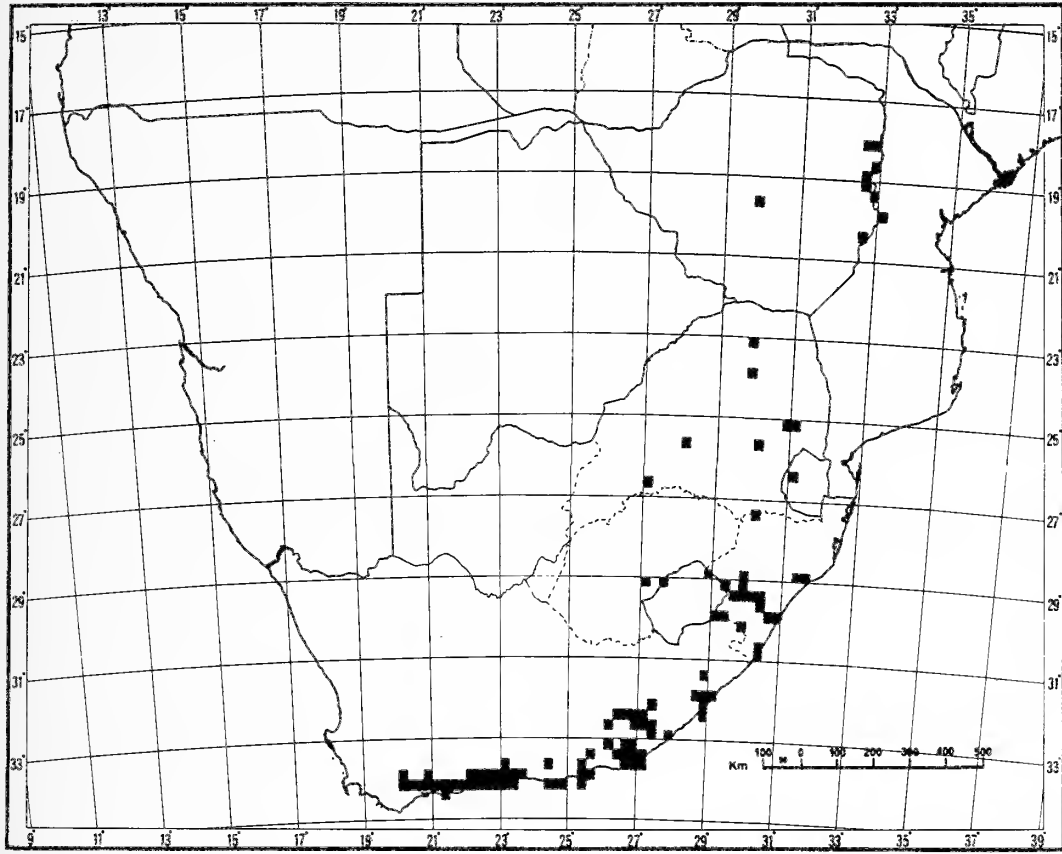


Fig. 16

Distribution of *Rana fasciata* Smith in southern Africa plotted on the latitude/longitude grid.

Poynton 1964), to Bonnievale (3320 CC Montagu). *Rana montana* is shown to have a wider distribution range than previously noted; it occurs in the Cedarberg Mountains (3219 AC Wuppertal) and eastwards to the Outeniqua Pass (3322 CD George).

Two nocturnal collecting trips have been made to Prince Alfred's Pass east of George (3323 CC Kruisvallei) where *R. montana* might also be expected to occur but it was not found, perhaps, because of unsuitable weather conditions.

*Rana montana* is probably always found together with its relative *R. grayii*, but the latter is a much more abundant and ubiquitous frog. We have never found *Rana montana* specimens easy to acquire by night-collecting (see, however, life history notes), and it does not appear to form numerically strong localised choruses like *Rana fasciata*. A table of spot localities for known populations of *R. montana* is therefore provided below, which may prove useful to investigators of this species' life history (Table 1). The locus name and number correspond with the South African 1:50 000 map series designation; these maps should be used for spot locality identification.

Fifty-four loci for *Rana fasciata* additional to those provided by Poynton (*op. cit.*) are also tabulated (Table 2). Of particular interest are those from the same localities as *Rana montana*, so recorded in the column set aside for "notes".

TABLE 1.

Spot localities for known *Rana montana* populations.

Locus	Locus Name	Spot Locality	Altitude (m)	Notes
3219 AC	Wuppertal	32° 28'22"S; 19° 09'30"E	1 220	Coll. R. Haynes in Cedarberg State Forest at Hoogvertoon. C.D.N.C. 4711
3319 AA	Groot-Winterhoek	33° 03'16"S; 19° 04'47"E	640	Coll. R. Haynes at Driebosfontein. C.D.N.C. 4706
		33° 04'28"S; 19° 06'02"E	680	Coll. D. Pepler at "De Tronk", near "Groot-Winterhoek", on 12/xii/1976
3319 AC	Tulbagh	33° 24'45"S; 19° 07'19"E	450	Coll. R. Haynes at Kluitjieskraal
3319 AD	Ceres	33° 29'17"S; 19° 19'13"E	1 670	Coll. C. Gow at U.C.T. Mountain Club Hut, 1.5 km south of Waaihoek Peak, 25/iv/1965
3318 CD	Kaapstad/Cape Town	33° 58'22"S; 18° 23'58"E	760	Poynton's record based on S.A.M. specimen labelled "Table Mountain". Confirmed by specimen in S.A.M. collected by C. Gow at the Mountain Club Hut on Table Mountain on 2/i/1965
		33° 58'43"S; 18° 24'54"E	745	Coll. E. van Jaarsveld. In S.A.M. collection
3318 DC	Bellville			Based on S.A.M. specimen labelled "Cape Flats". Doubtfully present in this locus now, but specimen in any case could have been collected in 3318 CD Kaapstad/Cape Town
3318 DD	Stellenbosch	33° 59'36"S; 18° 57'11"E	395	Coll. R. Haynes, Swartboschkloof, Jonkershoek State Forest
3319 CC	Franschhoek	33° 52'14"S; 19° 02'49"E	185	C.D.N.C. 4410. Wemmershoekvlei Plateau to the north-west of Wemmershoek Dam. R. A. Haynes 19/x/1977
		33° 48'18"S; 19° 03'26"E	595	
		33° 57'20"S; 19° 10'35"E	380	"Purgatory" outspan at east end of Franschhoek Pass. C.D.N.C. 4719
3319 CD	Villiersdorp	33° 57'01"S; 19° 18'13"E	550	In the Elandsrivier Valley (tributary valley, the "Langkloof") 4 km north of Villiersdorp
3320 DD	Warmwaterberg	33° 59'29"S; 20° 51'13"E	185	In a marsh at "Goede Hoop", Grootvadersbos. C.D.N.C. 4623
3321 CC	Muiskraal	33° 57'24"S; 21° 13'37"E	c. 455	Near the Vetrivier, Garcia's Pass
		33° 57'49"S; 21° 13'17"E	c. 425	Near the Vetrivier, Garcia's Pass

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Locus	Locus Name	Spot Locality	Altitude (m)	Notes
3322 CC	Jonkersberg	33° 56'02"S; 22° 13'39"E 33° 55'43"S; 22° 13'34"E 33° 55'44"S; 22° 13'41"E 33° 51'44"S; 22° 02'39"E 33° 51'52"S; 22° 01'49"E 33° 55'09"S; 22° 01'27"E	305 410 410 610 745 455	In the valley beside Jonkersberg Forest Station C.D.N.C. 4612. Topotypical material C.D.N.C. 4613. Topotypical material North side of Robinson Pass, in the Moerasrivier valley. <i>Rana fasciata</i> also here North side of Robinson Pass South side of Robinson Pass
3322 CD	George	33° 54'37"S; 22° 24'39"E 33° 54'20"S; 22° 24'27"E 33° 53'19"S; 22° 24'06"E	505 550 655	In Outeniqua Pass north of George In Outeniqua Pass north of George Just below the top of the Outeniqua Pass on the south side
3418 AB	Simonstad/Simonstown	34° 05'29"S; 18° 25'20"E 34° 13'26"S; 18° 24'15"E 34° 14'46"S; 18° 23'12"E 34° 06'26"S; 18° 26'56"E	290 75 45 410	Montane marshy "fynbos". C.D.N.C. 4621; 4708. Steenberg Plateau Coll. H. Langley at Modderdam, Cape Point Nature Reserve. C.D.N.C. 4710 Coll. B. Rose and R. C. Boycott near Olifantsbos, Cape Point Nature Reserve. C.D.N.C. 4703 Coll. D. Herrington at Nellie's Pool on Muizenberg Mtns. C.D.N.C. 4709
3418 BB	Somerset West	34° 09'06"S; 18° 56'23"E	c. 395	To the east of Sir Lowry's Pass, Hottentots Holland Mountains
3419 AA	Grabouw	34° 09'19"S; 19° 08'28"E 34° 09'22"S; 19° 08'31"E 34° 10'09"S; 19° 09'51"E 34° 09'28"S; 19° 09'27"E 34° 08'50"S; 19° 08'23"E 34° 00'26"S; 19° 00'35"E 34° 05'26"S; 19° 03'09"E 34° 04'19"S; 19° 03'59"E	670 670 655 825 885 1 220 490 490	Lebanon State Forest. C.D.N.C. 4702 Lebanon State Forest. C.D.N.C. 4704 Lebanon State Forest. C.D.N.C. 4712 Lebanon State Forest. C.D.N.C. 4707 Coll. J. W. Esterhuysen, Lebanon State Forest. 6/ii/1974 Coll. R. Haynes at Dwarsberg in Jonkershoek State Forest. C.D.N.C. 4705 2½ km due south of Nuweberg Forest Station in Viljoen's Pass 0,5 km on north side of Viljoen's Pass 10 km north of Grabouw
3419 AB	Caledon	34° 13'19"S; 19° 28'59"E	335	Above the farm "Voorhoede" east of Caledon, in the hills
3419 BA	Greyton	34° 13'24"S; 19° 31'16"E	275	In the hills near the national road 8½ km east of Caledon
3420 BB	Heidelberg (Kaap)	34° 00'06"S; 20° 51'23"E	170	In a marsh on the farm "Goede Hoop"
3421 AA	Groot-Kragga	34° 01'27"S; 21° 13'50"E 34° 01'15"S; 21° 13'54"E	150 150	Vetriver valley below Garcia Forest Station. <i>Rana fasciata</i> also here In a marsh immediately to the west of Garcia Forest Station
3418 AD	Simonstad/Simonstown	34° 18'13"S; 18° 25'19"E	80	Cape Point Nature Reserve, Klein Blouberg

Locus	Locus Name	Spot Locality	Altitude (m)	Notes
3418 BD	Hangklip	34° 20'40"S; 18° 50'50"E 34° 16'38"S; 18° 59'52"E	25 110	C.D.N.C. 4699; C.D.N.C. 4701 Coll. B. Durand, Kogelberg State Forest. 26/viii/1975
3419 AC	Hermanus	34° 20'11"S; 19° 03'30"E 34° 19'18"S; 19° 09'38"E 34° 20'00"S; 19° 03'10"E  34° 19'42"S; 19° 05'26"E 34° 19'03"S; 19° 07'15"E	15 40 15  30 45	Coll. C. Burgers. C.D.N.C. 4016 Hills on east side of Botrivier C.D.N.C. 4594. Sonogram in this paper is from this specimen East of Lamloch at Kleinmond In hills to the west of Botrivier/Kleinmond road. Several localities along this road
3419 AD	Stanford	34° 24'24"S; 19° 19'13"E  34° 23'40"S; 19° 16'00"E 34° 19'00"S; 19° 24'37"E  34° 19'24"S; 19° 22'05"E	10  90 245 200	Marsh next to sea at mouth of Voëlgatrivier, 2 km east of Hermanus. C.D.N.C. 4700 In Fernkloof Nature Reserve, Hermanus South side of Shaw's Mountain Pass, on the farm "Hartebeesrivier" Below Shaw's Mountain

TABLE 2.

Loci for *Rana fasciata* populations not recorded by Poynton (1964) with altitudes of sampled populations

Locus	Locus Name	Altitude (m)	Notes
2530 BB	Sabie	1 190	See text
2929 CC	Bushman's Nek		
3128 DC	Elliotdale	670	
3128 DD	Mqanduli	670	
3129 CC	Coffee Bay	90	
3226 AD	Spring Valley	1 615	
3226 BC	Hackney	1 660	
3226 BD	Fairford	1 400	
3226 CA	Bedford	790	
3226 DB	Seymour	1 280	
3227 AB	St. Marks	1 065	
3227 AC	Cathcart	1 415	
3227 CA	Keiskammahoek	1 435	
3227 CB	Stutterheim	520	See text
3227 CD	King William's Town	560	

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Locus	Locus Name	Altitude (m)	Notes
3227 DD	Cambridge	120	
3228 BB	The Haven	455	
3228 BD	Dwesa	15	
3320 CC	Montagu	215	
3320 DD	Warmwaterberg	200	Shared locality with <i>R. montana</i>
3322 CC	Jonkersberg	355, 610	Shared locality with <i>R. montana</i>
3322 DC	Wilderness	10	
3322 DD	Karatara	215	
3323 CD	The Craggs	15, 230	
3323 DC	Nature's Valley	15	
3324 CB	Akkerdal	305, 670	
3325 BC	Coerney	105	
3325 CB	Uitenhage (Noord)	120	
3325 CD	Uitenhage	180	
3325 DC	Port Elizabeth	90	
3326 AA	Riebeek-Oos	655	
3326 BA	Fort Brown	400	
3326 BB	Breakfast Vlei	170	
3326 AD	Salem	370	
3326 BD	Trappe's Valley	400	
3326 DA	Boesmansriviermond	50, 270	
3327 AC	Prudhoe	185	
3327 CA	Great Fish Point	15	
3420 AA	Stormsvlei	105	
3420 AB	Swellendam	105, 120	
3420 BA	Suurbraak	75, 105	
3420 BB	Heidelberg (Kaap)	170, 365	
3421 AA	Groot-Kragga	135, 170	Shared locality with <i>R. montana</i>
3421 AB	Riversdale	105, 425	Probable source of FitzSimons' Garcia material
3421 BA	Albertinia	200	
3421 BB	Herbertsdale	170	
3422 AA	Mosselbaai	15, 160	
3422 AB	Pacaltsdorp	170	
3422 BA	Wilderness	90	
3422 BB	Sedgefield	10	
3423 AB	Plettenbergbaai	215	
3424 AB	Clarkson	215	
3424 BA	Kruisfontein	170	
3425 AB	Uitenhage	135	

It is probable that the locus given by Poynton (1964) for FitzSimons' *R. montana* record from Grootvadersbos, 3320 CD Scheepersrus, is incorrectly cited (Poynton, pers. comm.). FitzSimons' locality was "Langebergen, above Grootvadersbosch", but Grootvadersbos is not indicated on the 1:500 000 map of the area, and the word "Langeberge" is printed on the locus 3320 CD. However, both the farm "Grootvadersbos" and the forest of the same name actually lie mainly in 3320 DD Warmwaterberg and 3420 BB Heidelberg (Kaap), and marginally in 3320 DC Barrydale and 3420 BA Suurbraak; no part of the estate lies in 3320 CD Scheepersrus. As stated below in the section dealing with the type-localities, we suggest that this record was obtained in 3320 DD Warmwaterberg.

Although the locality "Cape Flats" is cited for *R. montana* by Poynton (from British Museum and South African Museum material), we have been unable to confirm its occurrence in the locus cited, viz. 3318 DC Bellville. This locus has therefore been deleted from figure 6 until such time as the species' presence can be confirmed there. Old South African Museum specimens of *R. montana* are catalogued from "Rondebosch", "Table Mountain" and "Cape Flats". The latter specimen was collected in 1875 and accessioned only in 1896, which might suggest that the selection of a locality could have been somewhat arbitrary. The Cape Town suburb of Rondebosch lies partly on the Flats and partly on the lower slopes of Table Mountain; it lies in the locus 3318 CD Kaapstad/Cape Town. The Cape Flats proper, which lie largely in the loci 3318 DC Bellville and 3418 BA Strandfontein, have now been so altered by urbanisation, agriculture, and the uncontrolled spread of exotic vegetation, that any formerly suitable habitat for *Rana montana* has now all but disappeared.

All other *Rana montana* loci cited on Poynton's map have been confirmed by recent collections.

It will be noted from Fig. 16 that the locality given by Poynton (*op. cit.*) for the FitzSimons *R. fasciata* specimen from "Garcia" has been changed from 3321 CC Muiskraal to 3421 AB Riversdale. FitzSimons (1946) acknowledged the assistance of Mr H. J. Vockins who was the forester at Garcia in November 1940, and who now lives in retirement at George. We approached the latter for information as to FitzSimons' collecting sites, and in his recollection, the site where the *R. fasciata* was collected was at the "Perdedam" in the Garcia Plantation. This locality was accordingly visited, and despite an initial impression of unsuitability of habitat, we found *Rana fasciata* calling in indigenous vegetation along a stream in a pine plantation at 10.30 a.m. at an altitude of 425 m. It is suggested that this locality be regarded as the source of *Rana fasciata* T.M. 20099. As a matter of interest, *R. montana* was heard calling in a marsh just below the Garcia Forest Office that same morning (3 August 1978) at an altitude of only 150 m, and only 300 m distant from another *Rana fasciata* population calling at an artificial pond.

The locality given by Poynton for an Albany Museum *R. fasciata* specimen from "Hogsback", 3227 CA Keiskammahoek, should perhaps have been cited as 3226 DB Seymour, as we interpret the label to mean the Hogsback holiday resort and township and not the mountain of the same name. *R. fasciata* is abundant in the forest glades nearby. We have, however, confirmed the species from both Hogsback township (3226 DB) and from below the Hogsback Mountain (3227 CA).

### THE TYPE-LOCALITIES

The type-locality of *Rana montana* is "the upper slopes of the Jonkersberg, Attaqua Mountains" (FitzSimons 1946). FitzSimons used the Jonkersberg Forest Station as his base in November 1940 and it is reasonable to suppose that the type specimen was collected within the forest limits, above the forest offices. We have heard the species calling within 300 metres of the office complex, and caught two calling males in natural vegetation within the pine plantations 75 m in altitude above the station and 650 m to the north-east. FitzSimons claimed that all his

specimens (two from Jonkersberg and four from Grootvaderbos) were “taken in grass-covered marshy hollows on the higher mountain slopes, at an altitude of 3–4 000 ft.” (900–1 200 m). In both places he could have collected them within 500 m of his camp-sites on the lower slopes, but this would not conform to the stated altitudes. The type-locality may with confidence be restricted to the mountain slopes in the Jonkersberg State Forest (holotype T.M. 20223; 3322 CC Jonkersberg).

The paratypes (T.M. 19966–9 and T.M. 20222) were collected respectively at Grootvadersbos and Jonkersberg. As stated earlier, the Grootvadersbos estate lies in four loci, but marginally in two of these. The main section lies in the locus 3320 DD Warmwaterberg including the large section of indigenous forest and the State Forest plantations. A timber extraction track which existed in 1940 runs up the mountain from the forest station to the natural forest Boesmansbos, and passes through “grass-covered marshy hollows . . . at an altitude of 3–4 000 ft.”. We have in fact a record of *R. montana* from Helderfontein above Boesmansbos at 3 900 ft (1 190 m). It is almost certain that these paratypes were collected in 3320 DD Warmwaterberg.

*Rana fasciata* is interpreted by reference to the lectotype B.M. 58.11.25.127 with the locality “Africa”, collected by Sir Andrew Smith. The type-locality may never be ascertained with accuracy.

### LIFE HISTORY NOTES

Very little is known of the life history of *Rana montana*, although much of the detail provided by Rose (1962, and in the 1950 edition of the same book) under the name of *R. fasciata*, in fact refers to *R. montana*. We present the following incomplete notes with some diffidence.

Both species are confined to areas of high rainfall (over 500 mm per annum), and are rarely found far from permanent water. *R. fasciata*, however, appears to prefer long grass and reeds adjacent to streams, ditches and dams with relatively deep water; relatively deep that is, when compared with *R. montana* which is associated with marshy areas and seepage zones with shallow trickles of water.

A normal *R. fasciata* chorus consists of many males closely spaced, often only half a metre apart, while calling *montana* males are usually at least two or three metres apart. This is of course attributable to the difference in breeding site; the “coastline” of a marsh is much longer than that of a pond, and the *montana* males are not forced to jostle for a water’s edge territory. Both species appear to be winter breeders.

It is our impression that *Rana fasciata* benefits by man’s agricultural activities. It is commonly found around well-vegetated farm dams, in damp areas near irrigation canals, and in town gardens; it is often found in exotic vegetation. *Rana montana*, on the other hand, is probably intolerant of disturbance; we have never found it in anything other than natural veld, and it does not seem to occur for example in Hermanus or Kleinmond, although these towns have been built on what is presumed to have been formerly *R. montana* habitat. This may be because garden simulation of a *fasciata* breeding site is a simpler matter than that of a *montana* breeding site.

Frog collections are often made at night, when calling males can be tracked down by ear and captured. This is especially easy if the frogs concentrate around a circumscribed breeding site as in the case of *R. fasciata*, but difficult in the case of *R. montana* whose calling males are dispersed over a wide area. Consequently, specimens of *R. montana* are not numerous in museum collections.

Specimens collected for our survey by colleagues and Forestry Department personnel were largely obtained during the day, suggesting that *R. montana* is at least partially diurnal. One of us (A. L. de V.) collected eighteen specimens in just over one hour in an 80 m × 40 m area of damp ericoid-restioid fynbos on the Steenberg Plateau (10/ix/1978), and twenty in 45 minutes in a 70 m

× 35 m area near Nellie's Pool a week later (both 3418 AB Simonstad/Simonstown), in the late afternoon. A similar number was collected by D. Herrington under similar conditions in July 1976. The frogs were found jumping through short ( $\frac{1}{2}$  metre) vegetation on disturbance, in damp seepage zones.

The positions adopted by calling males of *R. fasciata* and *R. montana* are similar, depending upon the cover. If tall reeds or rushes are present, *fasciata* males will clamber up to two metres above water level and call from a spread-eagled position clasping two or even three separate stalks; if the water's edge is surrounded by tussocks of grass, the males will call at water level, crouching on the ground below grass cover, or in the open.

*R. montana* males have been found calling from the crouching position at water level below an overhanging tussock of a short restioid sedge 8 cm high in a marsh at Grootvadersbos. In the Jonkersberg State Forest they called from within a dense mat of interlaced ferns about  $1\frac{1}{2}$  metres deep, overhanging a runnel of water below a road embankment. At Kleinmond they called from a roadside ditch 10–20 cm above ground level spread-eagled between tall grass stems.

The eggs of *Rana montana* are probably laid, like those of *grayii*, not far from the water's edge, but not in water. At the Jonkersberg State Forest we found a batch of 39 eggs on a waterlogged moss/earth substrate about 6 cm from a shallow runnel of water at the edge of a level road below a bank overhung with ferns. These eggs were lying singly, or in groups of up to six or seven attached in rows. The only frog found here was *R. montana* and the assumption is that these were *montana* eggs. Rose (1962) also states for *fasciata* (= *montana*) that he found some "capsule" eggs by the side of an upland trickle, which could never have reached to them; from these eggs he reared *fasciata* (= *montana*) froglets. The Jonkersberg egg capsules averaged 7 mm in diameter (6.0–7.6 mm).

It is interesting to note that although *Rana fasciata* is generally supposed to lay its eggs in water (Wager 1965), Stewart (1967) records that the subspecies *fuelleborni* lays its eggs out of water on sedge blades above the water, or on moist earth an inch above water level. Stewart erroneously attributes Rose's remarks on "*Rana fasciata montana*" to *Rana fasciata fasciata*.

A single trombiculid mite was found on an adult male *R. montana* from Jonkersberg State Forest (specimen C.D.N.C. 4613, see table 1). It was visible as a minute reddish speck on the sole of the left foot in soft tissue immediately below the webbing between the second and third toes. The frog was placed in formalin before the mite was noticed, rendering the latter unsuitable for identification. Such mites should be preserved directly in 70% ethanol taking care not to damage the mouthparts when removing them from the host.

#### THE NAME *RANA MONTANA*

The elevation of FitzSimons' subspecies to species level is straightforward. "*montana*" is a species-group name and was applied by FitzSimons with due regard to the dangers of synonymy. In other words, there is no evidence of previous usage of the name *montana* in the genus *Rana*, and there is thus no impediment in the way of its employment despite the fact that the species is not necessarily montane in its habitat preference. The full citation, if desired, should read *Rana montana* FitzSimons, 1946.

Tschudi in 1838 proposed the genus *Strongylopus* for his concept of Boie's *Rana fasciata*, as *Strongylopus fasciatus*. Steindachner (1867) employed the same genus for *Rana grayii*. Parker and Ride (1962) of course showed that Boie's "*Rana fasciata*" was probably what we now know as *R. grayii* (see section dealing with the taxonomic history of the name *Rana fasciata*).

Although Poynton (1964) and the majority of his predecessors placed the species *fasciata* and *grayii* in the genus *Rana*, Van Dijk (1966, 1971) revived *Strongylopus* as a genus and used it for *R. fasciata*, *R. grayii*, *R. wageri* and *R. hymenopus*, without however, publishing the diagnostic characters justifying the separation of the two genera. Parker and Ride (1962) in fact



suggested that *Strongylopus* might be found useful as a subgenus of *Rana*; this suggestion appears to us to have some merit, at least in respect of *R. fasciata*, *R. grayii* and *R. montana*.

*Strongylopus* as used by Tschudi is masculine in gender. If used as a generic name for the species *fasciata*, *montana* and *grayii*, therefore, the former two names would become *fasciatus* and *montanus*. If *Strongylopus* is used as a subgenus, however, no alteration in the specific name is required, as the specific name agrees in gender with the generic name, e.g. *Rana (Strongylopus) montana*. The citation "*Strongylopus (Rana)*" as used by Van Dijk (1971; 1977) to indicate equivalence of the two genera is incorrect. By convention, subgenera are cited in parenthesis between the generic and specific names. It is best to indicate an alternative generic name by the use of an "equals" sign, e.g. *Strongylopus* (= *Rana*) *grayii*.

The choice of a vernacular name for *Rana montana* is not straightforward. If the specific epithet is anglicised, the resulting name would be the "montane frog" or "mountain frog" which would be misleading in view of its occurrence in coastal marshes. *R. fasciata* has been anglicised in this way and has been called the "striped rana", "striped frog", "striped grass-frog" and "long-toed grass frog". Despite the fact that sedges of the family Restionaceae rather than true grasses dominate the habitat of *R. montana*, we feel that "grass frog" fulfils a useful role as a vernacular "generic" name for *fasciata* and *montana*, and we therefore tentatively suggest that they could be called respectively the "striped grass frog" and the "Cape grass frog".

#### TAXONOMIC HISTORY OF THE NAME *RANA FASCIATA*

The history of the name *Rana fasciata* is marked by confusion over authorship and mistaken identity. Authorship has been variously ascribed to Tschudi (FitzSimons 1946), Boie (Hewitt 1911), and Smith (Poynton 1964). Parker and Ride (1962), however, pointed out that the name was first proposed by Burchell (1824). The background to this confused state of affairs was succinctly presented by Parker and Ride (*op. cit.*) in an application to the International Commission on Zoological Nomenclature. They claimed, apparently correctly, that the names *Rana fasciata* and *Rana grayii*\* were popularly assigned to the wrong frogs, and that if the law of priority were to be strictly enforced, the species now known as *R. grayii* would have to become *R. fasciata*, while the species now referred to as *R. fasciata* would require a new name altogether. In the interests of stability in nomenclature, therefore, they proposed that the currently used names should be retained by the exercise of the Commission's plenary powers, and they further requested the Commission's blessing for a proposed neotype for *R. fasciata* and a lectotype for *R. grayii*. This application was supported by Poynton (1963). The matter was settled finally by Opinion 713 of the Commission (China 1964).

As Parker and Ride were of course ignorant of the existence of *Rana montana*, which bears a superficial resemblance to *R. fasciata sensu* Smith, and as they based part of their submission regarding the true identity of Burchell's *Rana fasciata* on what appears to be faulty reasoning, a brief summary of their 1962 application and the Commission's subsequent findings is provided here.

- (1) The case concerned *Rana fasciata* Burchell, 1824, and *Rana grayii* Smith, 1849.
- (2) Burchell (1824) described a new species of frog, *Rana fasciata*, from 30°05'S; 23°28'E. It was "a very pretty and new species of frog of a green colour, and marked

\*Note: This species was described by Smith (1849), who used the spelling "grayii". All subsequent authors except FitzSimons have "corrected" this to "grayi". The "correct original spelling", however, is "*Rana grayii*" (Article 32, International Code of Zoological Nomenclature, 1964), which spelling should henceforth be used. It should be noted too that the same stricture applies to four other southern African frogs. These are *Tomopterna* (= *Pyxicephalus*) *delalandii*, *Hyperolius* *horstockii*, *Kassina* *wealii* and *Leptopelis* *bocagii*, where the specific epithet variants *delalandei*, *delalandi*, *horstocki*, *wealei* and *bocagei* are no longer acceptable.

by a longitudinal yellow stripe on its back, and by transverse stripes of brown on its hind legs". He also stated that it was a silent frog which croaked very seldom. It was found on the 3rd March 1812. No type-specimen has been traced and no sketch or figure exists (see below).

- (3) Boie (1832) stated that he collected *Rana fasciata* Burchell near Muizenberg on the Cape Peninsula.
- (4) Tschudi (1838), unaware of Burchell's work, proposed a new genus *Strongylopus*, with *Rana fasciata* as type-species, citing Boie incorrectly as author.
- (5) Duméril and Bibron (1841) described four varieties of Tschudi's *Strongylopus fasciatus* (= Boie's *Rana fasciata*).
- (6) Andrew Smith (1849) realised that Duméril and Bibron had more than one species in their four varieties, and named one of them *Rana grayii*. He also described and figured "*Rana fasciata* Boie" corresponding to variety D of Duméril and Bibron. Since 1849 the name *Rana fasciata* has been consistently applied to the form illustrated under that name by Smith.
- (7) Parker and Ride examined the specimens used by Duméril and Bibron and confirmed that Smith was correct in dividing them into two species. They also confirmed that "variety D" corresponded with Smith's figure of *R. fasciata*. Duméril and Bibron believed this variety to include the Leiden Museum specimens labelled *R. fasciata* by Boie, and Boie of course believed these to belong to the species described by Burchell. Parker and Ride therefore deemed it correct to use the name "*Rana fasciata* Burchell" for the species known popularly until 1962 as "*Rana fasciata* Boie" or "*Rana fasciata* (Tschudi)".
- (8) Unfortunately Boie's two surviving specimens at Leiden are both referable to Smith's *R. grayii*.
- (9) Therefore the current concept of *Rana fasciata* is based on Smith's acceptance of variety D of Duméril and Bibron as *Rana fasciata*; these authors in turn believed their variety D corresponded to Boie's Leiden specimens labelled *R. fasciata*, which Boie of course believed to correspond to Burchell's *Rana fasciata*, but which correspond in fact to Smith's *Rana grayii*.
- (10) This meant that if Boie correctly applied Burchell's name, the species now known as *R. grayii* would have to be known as *R. fasciata*, and the species now known as *R. fasciata* would require a new name.
- (11) Parker and Ride then selected a neotype for *Rana fasciata* Burchell (*sensu* Smith) from Smith's material in the British Museum (locality "Africa"), and a lectotype for *Rana grayii* Smith also from Smith's collection, and requested that the Commission preserve stability of nomenclature by using its plenary powers to direct that *Rana fasciata* Burchell, 1824 be interpreted by reference to that neotype, and that *Rana grayii* Smith, 1849 be interpreted by reference to that lectotype.

Poynton (1963) supported the application, pointing out that Burchell's description was inadequate and that it could not be demonstrated unequivocally that *R. fasciata* Burchell is *R. grayii* of later authors.

Professor Hobart Smith agreed with the need to preserve the name *Rana fasciata* in its accustomed sense (i.e. *sensu* A. Smith), but proposed an alternative means of achieving this, viz. by suppressing the name *Rana fasciata* Burchell, 1824, together with all other uses of the same name prior to that by Andrew Smith in 1849, and that the proposed neotype for Burchell's species selected by Parker and Ride (one of Smith's specimens) should be designated as a lectotype of *Rana fasciata* A. Smith, 1849.

The Commissioners voted to suppress the name *Rana fasciata* Burchell, 1824, and all other

uses of the specific name *fasciata* in the combination *Rana fasciata* prior to that by Smith, 1849. They also voted to accept both the *Rana grayii* lectotype designated by Parker and Ride, and the specimen designated by them as neotype of *Rana fasciata* as the lectotype of *R. fasciata* Smith, 1849 (China 1964).

As the lectotype of *Rana fasciata* Smith, 1849 in the British Museum bears no more precise locality on its label than "Africa", two pertinent questions arise from the mélange of misconceptions described above.

(a) does the recognition of *Rana montana* as a species in its own right in any way affect the selection of the *Rana fasciata* lectotype by Parker and Ride?

(b) what was the species which Burchell named *Rana fasciata*?

Firstly, let us take the case of the *Rana fasciata* lectotype whose type-locality, "Africa", could hardly be more vague. Fortunately, Smith published an illustration of his concept of *Rana fasciata*, and Parker and Ride (1962) and Poynton (1963) believed that the selected lectotype (B.M. 58.11.25.127) may well have been the one used in the preparation of this illustration (Smith, 1849, pl. 78, fig. 1). This plate is reproduced here (Fig. 17). As has been pointed out earlier (in section dealing with colour markings), *Rana montana* possesses well-marked transverse bands on the tibia while *R. fasciata* has longitudinal tibial markings; Smith's plate clearly shows a frog with the tibial markings of *Rana fasciata*. Thus the lectotype of *Rana fasciata* in the British Museum was correctly selected, and the separation of *Rana montana* as a distinct species causes no upset in existing taxonomic arrangements.

The second problem is that of the identity of Burchell's *Rana fasciata*. This was collected at 30° 05' S; 23° 28' E, i.e. in the locus 3023 AB Good Hope, in the heart of the Karoo. Reference



Fig. 17. Smith's (1849) illustration of *Rana fasciata* on which the selection of the lectotype was based

to Poynton's (1964) distribution maps, and to figures 6 and 7 in this paper, shows that this frog could scarcely have been *Rana fasciata* Smith, 1849, which in the Cape is confined to the wetter coastal regions. It is also very unlikely to have been *Rana grayii*, although Poynton did examine a specimen of this species apparently collected at Vosburg (3022 DB Vosburg) approximately 80 km to the south-west in the collection of the Department of Zoology, University of the Orange Free State. Van Dijk (1971) draws attention to the fact that *Rana grayii* has adapted well to living in poplar plantations and points out that Karoo farms often possess such poplar groves maintained by borehole water. In Burchell's day this was of course not the case. Parker and Ride, who were not familiar with South African conditions, enlisted the aid of the South African herpetologist, the late Walter Rose of Cape Town, to find a solution. It may be presumed that they gave Rose the alternatives as *R. grayii* and *R. fasciata*, together with Burchell's descriptive notes (i.e. a green frog, with a single longitudinal yellow dorsal stripe, transverse brown stripes on its hind legs, a short small body and of a taciturn nature). Rose correctly replied that *R. fasciata* Smith, 1849 is never green "though this is the prevalent colour of *R. grayii*", that it has the more powerful call of the two species, and a markedly long and slender body. Quite apart from the fact that the Cape Town-based Rose was almost certainly describing *R. montana* (vide Rose 1962) rather than *R. fasciata* Smith, it is arguable that *Rana grayii* is not a noticeably green frog, but is perhaps better described as pale olive as Wager (1965) states; green and yellow are certainly not the first chromatic adjectives which spring to mind in regard to *Rana grayii*. It is difficult to see why the loudness of the call should be regarded as significant by Parker and Ride, as Burchell said only that "it was further distinguished by its silence, or at least by croaking very seldom". In any case a subjective decision on the relative power of the calls of *R. montana*, *R. grayii* and *R. fasciata* is hardly relevant.

On the other hand it could be postulated that *Rana fasciata* Burchell was in fact *Rana fuscigula* Duméril and Bibron, 1841. This frog is often bright green, often bears a single yellow vertebral stripe, has a short body, is not a particularly vocal species and might easily have been silent on 2nd March 1812 at the end of a hot dry Karoo summer. The locus 3023 AB Good Hope is clearly within the range of *Rana fuscigula* which has in fact been collected in the neighbouring locus 3023 AA Sodium. If Burchell's *Rana fasciata* was indeed *Rana fuscigula* of Duméril and Bibron, then *Rana fuscigula* would have become a junior synonym of *Rana fasciata*, and *Rana fasciata* Smith would have required a new name. However, the action of the International Commission in suppressing *Rana fasciata* Burchell, 1824 has fortunately obviated this situation.

Many of Burchell's sketches still survive. They were held in the library of the University of the Witwatersrand, Johannesburg, but later transferred to the Africana Museum, Johannesburg Public Library. The *Johannesburg Africana Museum Catalogue of Pictures*, vol. 6, contains reproductions of these sketches but the only amphibian illustrated by Burchell in 1812 was clearly a toad (B1941, number 17, sketch-book 3 of 1812). The compiler of the book implies in a descriptive note to B1941 that the toad is Burchell's *Rana fasciata*, but the date—4 September 1812—is too late for the collection date of *R. fasciata*, and the sequence of dates indicates that a frog collected in March would have been in sketch-book 1 or 2 of 1812.

(Note: The abbreviations used are as follows: T.M. (Transvaal Museum); S.A.M. (South African Museum); C.D.N.C. (Cape Department of Nature and Environmental Conservation.) The majority of the *Rana montana* specimens on which this paper is based are to be lodged in the collection of the Albany Museum, Grahamstown, South Africa. Others collected by the staff of the Department of Forestry, are lodged in their collection at Jonkershoek Forest Station, Stellenbosch, South Africa.)

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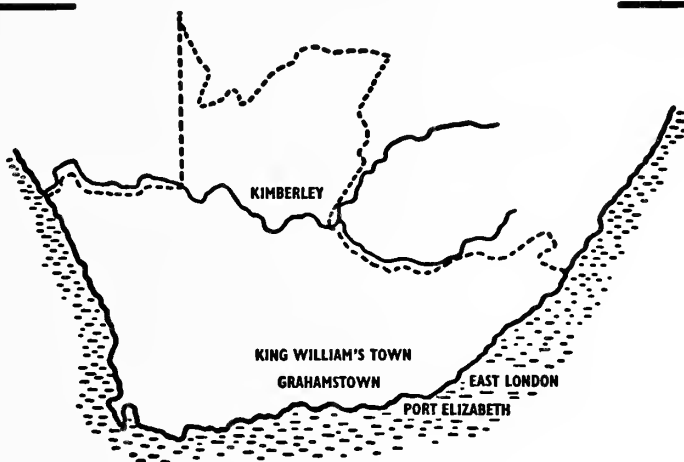
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# ANNALS OF THE CAPE PROVINCIAL MUSEUMS

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**Note on the type-locality, distribution and juvenile coloration of *Naja nigricollis woodi* (Serpentes: Elapidae) and an account of the colour-pattern variation in intergrade populations**

by

**RICHARD C. BOYCOTT**

(Port Elizabeth Museum)

and

**W. D. HAACKE**

(Transvaal Museum)

**INTRODUCTION**

The western black spitting cobra, *Naja nigricollis woodi* Pringle, 1955, occurs in southern South West Africa (Namibia) from the vicinity of the Namib Desert Park east of Walvis Bay, southwards through Great and Little Namaqualand to Porterville, and east to Prieska on the southern bank of the Orange River.

The Port Elizabeth Snake Park recently acquired a juvenile specimen of this little-known subspecies. As its coloration differs so markedly from that of fully-grown specimens, a description is provided here, along with an assessment of past distribution records for the subspecies and a redefinition of its type-locality. *Naja nigricollis woodi* integrades with *Naja nigricollis nigricincta* Bogert in western and central South West Africa. The change in colour-pattern from typical *woodi* to typical *nigricincta* within this region is also discussed.

**THE TYPE-LOCALITY**

The original description of *Naja nigricollis woodi* was based on three adult specimens collected near Citrusdal in the western Cape Province, South Africa (Pringle, 1955). The subspecies was named for its collector Mr John Wood of the South African Snake Farm, Fish Hoek, near Cape Town. A precise locality was not given in the original description nor has one been provided in any subsequent publication. However, Mr John Wood has confirmed that the type-specimens were in fact collected on the farm "Keerom" which is situated 29 km SSE of Citrusdal on the upper reaches of the Olifants River. It is suggested, therefore, that this farm should be accepted as the type-locality. Following the locality citation system laid down by Greig and Boshoff (in prep.) the locus (15' × 15' square) in which this farm falls is 3219 CC Keerom. (It is coincidental that the farm name should be the same as the locus name.)

**COLORATION NOTES AND DESCRIPTION**

One of the diagnostic characters used by Pringle (1955) to distinguish this subspecies was the black dorsal and ventral coloration in the specimens he examined. Attention has been drawn to this uniform coloration by various authors (FitzSimons, 1962, 1970; Broadley, 1968; Isemonger, 1968; and Visser and Chapman, 1978).

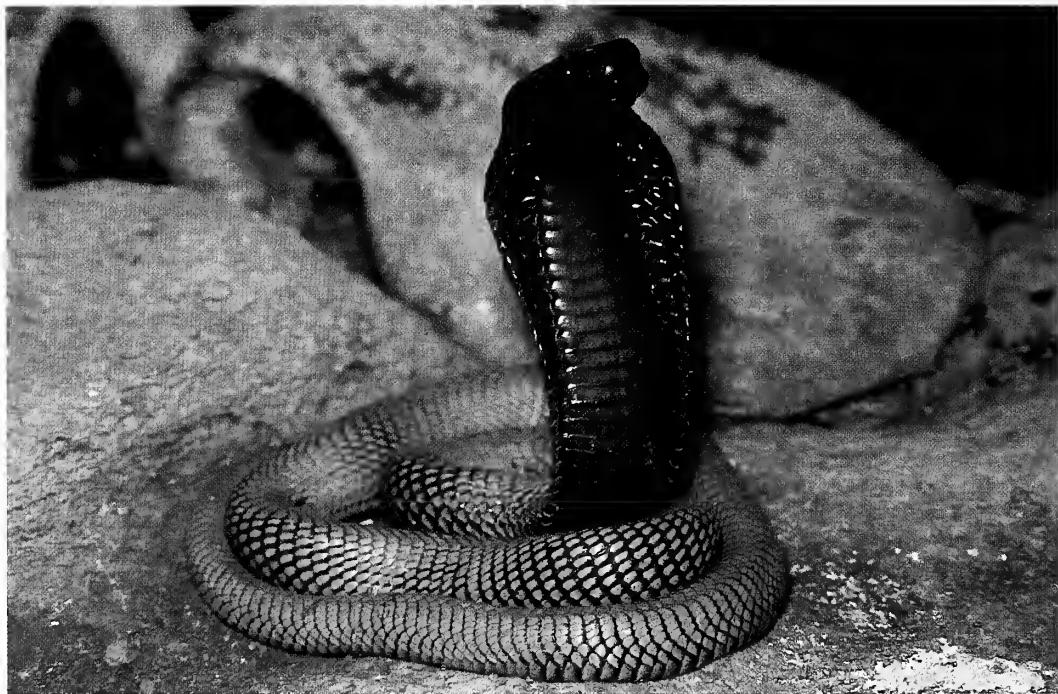


Fig. 1. *Naja nigricollis woodi* Pringle—juvenile specimen from Aninauspas, Little Namaqualand (PEM 152120).

The description provided by Mertens (1971) was based on an adult specimen (SMF 66021) from the farm Plateau and, although he stated that this adult female showed signs of grey colouring on the ventral surface, his description does not differ markedly from that provided by other authors. He questioned the locality data of SMF 21085 and commented on its atypical characteristics. Consequently this record has been excluded from the present account. Broadley (1974) drew attention to the difference in coloration between juveniles and adults, pointing out that juveniles between 550 and 700 mm in total length are "grey with the head and neck black".

The following more detailed description is based on a juvenile specimen (PEM 152120) collected near Steinkopf (2917 BA KOSIES. 29° 12'30"S; 17° 37'39"E. Altitude 775 m) on the road to Port Nolloth by Mr S. de Ridder of Springbok during April 1978 (Fig. 1). The vegetation type is classed by Acocks (1975) as Namaqualand Broken Veld.

*Dimensions*: 486 (407 + 79) mm.

*Sex and age*: Juvenile female.

*Scales*: The dorsal scales number 21 rows at midbody and 23 in the neck region. Ventral scales total 225 and subcaudals 65 using the method proposed by Dowling (1951). Anal scale entire, the first 6 subcaudals entire the remainder divided.

*Head shields*: Internasals 2, prefrontals 2, supraocular 1, parietals 2 with 9 bordering scales (i.e. temporals and nuchals). Each nasal shield divided medially by nostril, preoculars 2, postoculars 3, supralabials 6 the 3rd entering orbit, infralabials 8 the first three in contact with anterior sublinguals.

*Coloration*: Each ventral scale has a narrow margin of grey on its posterior edge which is absent in the first 30 ventrals. With this exception the entire ventral surface is black and the

throat is devoid of bands or stripes. The head, the sides and back of the neck are black; the rest of the dorsal surface and the sides are grey. At the base of each grey dorsal and lateral scale there is a margin of black; the overall effect is that of a fine reticulate pattern. This is further emphasized when the skin is distended, as the black interstitial skin is thereby exposed. Proceeding posteriorly from the neck region each body scale shows more grey, the black colouring diminishing until the overall grey colouring becomes completely dominant (subjectively around 20 scales from the parietals). A juvenile specimen from Porterville in the Transvaal Museum (TM 32784) conforms to this description.

DISTRIBUTION

The range limits of this subspecies have confounded herpetologists for many years, partly because of taxonomic uncertainty. Mertens (1955) mentions some specimens from the vicinity of Aus and Narudas Süd, considering them to be melanistic individuals of *N. nigricollis mossambica* Peters. FitzSimons (1962) believing it to represent a colour variety placed *Naja mossambica*

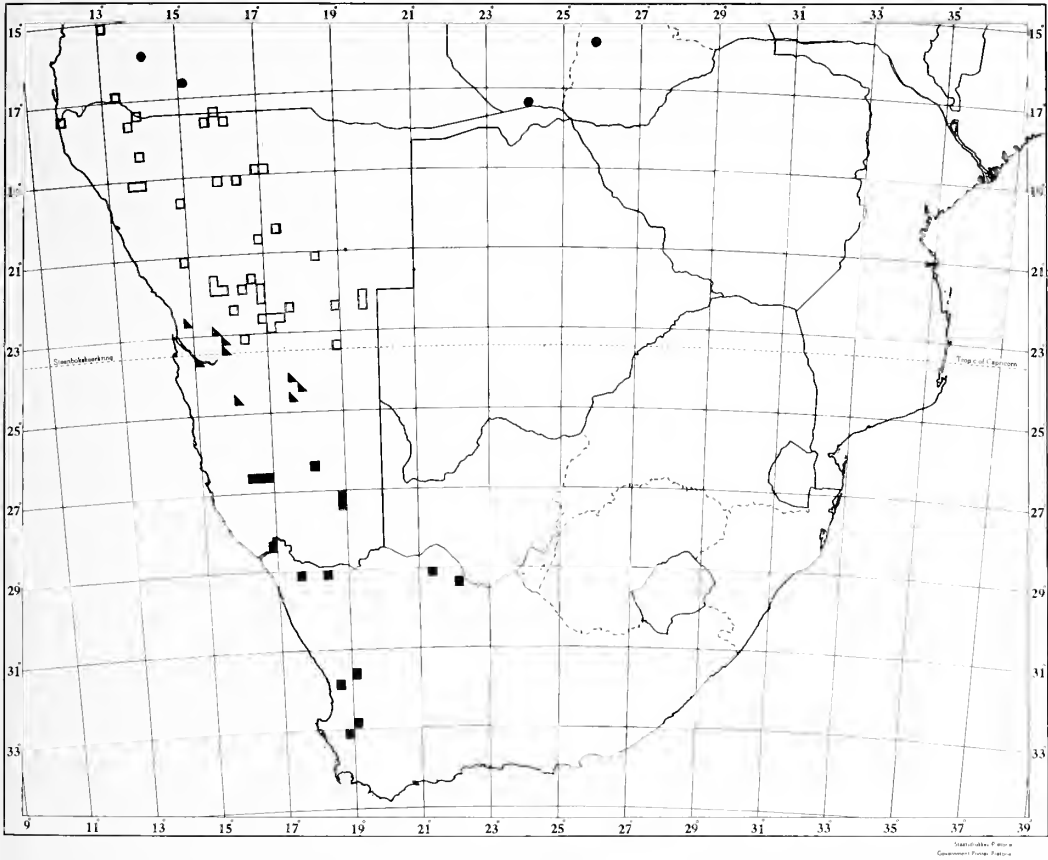


Fig. 2. ● *Naja nigricollis nigricollis* Reinhardt, □ *Naja nigricollis nigricincta* Bogert, ■ *Naja nigricollis woodi* Pringle, ▲ Indicates *nigricincta*/*woodi* intergrade populations.

Peters as a synonym under *Naja nigricollis* Reinhardt and recognised *nigricincta* Bogert and *woodi* as subspecies of the latter. Broadley (1968) separated *N. mossambica* and *N. nigricollis* and provisionally placed *nigricincta* and *woodi* as subspecies of *N. mossambica* to which Mertens (1971) agreed. After examining a larger series of specimens from south-western Africa, Broadley (1974) placed *nigricincta* and *woodi* as subspecies of *N. nigricollis*. Amongst the 15 specimens of *Naja nigricollis woodi* examined by him, he recorded that some showed signs of intergradation with *Naja nigricollis nigricincta*. Since Broadley's publication the Transvaal Museum has acquired additional specimens, some of which are intergrades. All in all sixteen specimens, eleven in the Transvaal Museum (TM 30172, TM 30462, TM 36603, TM 36881, TM 37183, TM 39962, TM 48166, TM 49786, TM 50675, TM 52154, TM 52155), four in the collection of the Namib Desert Research Station (NDRS R124, 125, 126, 127) and one in the State Museum (SM R1640), which are representative of nine distribution records (Fig. 2) appear to be *Naja n. nigricincta/woodi* intergrades. The intergrade zone between these two forms appears to be in western and central South West Africa between the latitudes 22°S and 25°S (Fig. 2). The distribution of *Naja nigricollis nigricincta* extends from southern central South West Africa northwards throughout the northern half of the country, excluding the Kungveld and Kavango-Capri area, to south-western Angola where it intergrades with *Naja nigricollis nigricollis*. The distribution records for *Naja n. nigricincta* (Fig. 2) have been taken from FitzSimons (1962), Broadley (1974) and newer additions to the Transvaal Museum collection. The records for *Naja nigricollis nigricollis* in south-western Angola and Zambia have been taken from Broadley (1974). The specimen illustrated (Fig. 3) is an intergrade between *Naja n.*



Fig. 3. *Naja nigricollis nigricincta/woodi*—juvenile specimen from Gobabeb, Namib Desert Park (TM 36881).

*nigricincta* and *Naja n. woodi*, collected at Gobabeb in the Namib Desert Park (TM 36881) and is typical for juveniles of that area.

Other juveniles of similar appearance have been collected, at the same locality (NDRS R127) and although without specific data, probably from the same general area (TM 52155). The juvenile (TM 36603) from Hardap Dam, *N. u. uigriciucta* according to Broadley (1974), is actually considerably darker than the juveniles from the Kuiseb River and the dorsal, white crossbands are even less distinct, for which reasons it must also be considered to be an intergrade. Adults of intergrade populations show some consistency within a population. Along the Kuiseb as far as the Desert Research Station, Gobabeb, they are dorsally more or less pitch black with a black collar which usually covers the first 18 or 19 ventrals, followed by one or two salmon pink to orange ventral scales (fading to white in preservative) and then irregularly alternating dark grey and white ventrals with black flecks scattered over both background colours. The whitish ventral markings in adults are best developed on the anterior third while the rear of the ventrum tends to be more uniform grey with flecks. This pattern is also found on TM 49786 from Kraaipoot, TM 48166 from Mooirivier and a specimen which was photographed in detail at close range by the junior author between Homeb and Hudaob in the Kuiseb River. A second specimen from Mooirivier (TM 39962) indeed gives the impression of a hybrid with *Naja uivea* as described by Broadley (1974). A new specimen from Voigtskub (TM 52154), a flat skin, is very close to a typical *N. u. woodi*, with a black dorsum and collar but the right tip of ventral 18 is white. This is equivalent to the salmon pink collar of the other dorsally black intergrades.

The adult specimens from Rostock (TM 30462), Onanesberg (NDRS R124) and Rössing (TM 50675) have a ventral pattern similar to that described above but dorsally on a black background indications of thin incomplete white transverse lines occur indicating their closer position to *N. n. nigricincta* than the lower Kuiseb population. This fits in with the clinal character of the intergrade zone, since the specimens from the Hakos Mountains (TM 24350, TM 34925) which are the closest true *nigricincta*, are rather dark specimens with comparatively poorly developed white transverse bands. The *uigriciucta* pattern is at its brightest in the Kaokoveld and south western Angola. Unfortunately only one intergrade specimen (MBL 1965, Quissange) has been described (Broadley, 1974) from the intergrade zone between the banded *N. n. nigricincta* and typical *uigricollis*, which is uniform black above with a black throat and a grey black speckled ventrum.

The change from one subspecies to another in *Naja nigricollis* through intergrade zones, is apparently correlated with a clinal change in the number of ventrals (Broadley, pers. comm.). Since further population analyses are pending by Broadley, this paper concentrated on clearing up some of the distribution record errors of *N. u. woodi*, to add new records and to provide more information on the change in pattern of populations of the intergrade zone between *woodi* and *nigricincta* without presenting any scale count data.

A list of localities is provided in Table 1. Ten of the localities post-date those provided by Broadley (1974). Locus citation follows Greig and Boshoff (in prep.). As the spelling of southern African place names is notoriously variable, the locality names are spelt according to the latest editions of the 1:50 000 Topographical series of South Africa and South West Africa.

#### GENERAL

The specimen figured by FitzSimons (1962) as *Naja uigricollis uigricollis* Reinhardt (TM 24653) from Que Que is in fact *Naja mossambica* Peters. In the field notes of *Naja uigricollis* (referring to *mossambica* as well) FitzSimons (1962) stated that they will usually "spit" from the reared position and also from ground level, without raising the head. *N. mossambica* is less inclined to rear and spread its hood than other cobras (Visser and Chapman, 1978). From 30 observations in the Port Elizabeth Snake Park during which both species were approached, *Naja nigricollis woodi* reared and elevated its head on all occasions. *Naja mossambica* raised its head

on only 3 occasions, and then only when directly threatened. Thus a distinct behavioural difference appears to exist between the two species. In captivity *N. n. woodi* has been known to eat toads, *Bufo* sp. (Wood, pers. comm.); the Port Elizabeth Snake Park specimen accepted laboratory mice.

#### MUSEUM ABBREVIATIONS

- MBL = Museum Bocage, Lisbon, Portugal.  
 NDRS = Namib Desert Research Station, Gobabeb, South West Africa (Namibia).  
 NM = Natal Museum, Pietermaritzburg, South Africa.  
 PEM = Port Elizabeth Museum, Port Elizabeth, South Africa.  
 SAM = South African Museum, Cape Town, South Africa.  
 SM = State Museum, Windhoek, South West Africa (Namibia).  
 SMF = Senckenberg Museum, Frankfurt, West Germany.  
 TM = Transvaal Museum, Pretoria, South Africa.  
 WNM = Wiesbaden Naturhistorisches Museum, Wiesbaden, West Germany.

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The authors would like to express their gratitude to the following for providing valuable information: Dr D. G. Broadley (Umtali Museum), Dr J. A. Pringle (Natal Museum), Dr G. R. McLachlan (South African Museum), Miss R. M. Tietz (McGregor Museum), and Mr M. Penrith (State Museum). Mr S. de Ridder of Springbok is thanked for supplying the juvenile specimen and Mr John Wood of the South African Snake Farm, Fish Hoek, for furnishing details regarding the type-locality. John Greig (Herpetologist, Cape Department of Nature and Environmental Conservation) is thanked for supplying information concerning the localities. The Board of Trustees of the Port Elizabeth Museum and the Director, Dr John Wallace are thanked for permission to publish this paper. Dr J. A. Pringle, John Greig and Allan Batchelor read the manuscript and provided useful suggestions.

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TABLE 1.  
Details of past and present distribution records for *Naja nigricollis* woodi Pringle and *N. n. nigricincta*/woodi intergrades

Locality	Previous Spelling	Mus. Cat. Number	Locus	Notes
Porterville, Piketberg dist., C.P.		TM 32784	3318 BB Porterville	Rec. by Broadley (1974)
Keerom, 29 km SSE of Citrusdal, C.P.		SAM 19926 TM 24247 NM 1136	3219 CC Keerom	Type-locality Prev. rec. as 3219 CA Citrusdal by FitzSimons (1962) and Broadley (1974)
Sewfontein, Nieuwoudtville dist., C.P.		SAM 44601 SAM 44602	3119 CA Lokenburg	Coll. C. T. Stuart 23/vi, 22/vii/1976. New distr. rec.
30 km NW of Clanwilliam on E bank of Olifants Riv., C.P.		SAM 44600	3118 DC Klawer	Coll. K. C. D. Hamman and C. M. Gaigher 26/xi/1974, New distr. rec.
Marydale, Prieska dist., C.P.		TM 49850	2922 AC Marydale	Don. R. Patterson 10/xi/1976. New distr. rec.
Klipkoppies, Kenhardt dist., C.P.		TM 50339	2921 AB Witdorp	Shed skin coll. by G. Newlands 27/ix/1977. New distr. rec.
Klein Nooisabes, E of Beenbreek, C.P.	Klein Nooi Sabris	SAM 3519	2918 AB Koisabis	Rec. by Broadley (1974)
Aninauspas, Little Namaqualand, C.P.	Anenous Pass	PEM 152120	2917 BA Kosies	Coll. S. de Ridder 21/iv/1978. New distr. rec.
Khubus, Richtersveld, C.P.	Kuboos	TM 25179	2916 BD Khubus	Rec. by FitzSimons (1962) and Broadley (1974)
Narudas Süd, Karasburg dist., S.W.A.		TM 5795	2718 BD	Rec. by FitzSimons (1962) as 2718 BB, and by Broadley (1974) as 2718 BC.
Kochena, Keetmanshoop dist., S.W.A.		TM 37384	2718 BB	Rec. by Broadley (1974)
30 km N of Keetmanshoop, S.W.A.		TM 49875	2618 AC Gariganus	D.O.R. coll. F. Odendaal April/May 1977. New distr. rec.
Kuibis, Bethanie dist., S.W.A.		WNM 1266 WNM 1326	2616 DB Guibes	First recorded by Lampe (1911). FitzSimons (1962) recorded it as 2616 AD. Mertens (1971) made no mention of the record. It is possible that these specimens were destroyed by bombs.
Plateau, Lüderitz dist., S.W.A.		SMF 66021	2616 DA Schakalskuppe	Coll. H. Emi 6/x/1955. Rec. by Mertens (1971) but not referred to by FitzSimons (1962) or Broadley (1974)

Aus, S.W.A.		TM 15641	2616 CB Aus	Rec. by FitzSimons (1962) as 2616 AC and by Broadley (1974) as 2616 CA.
Betw. Aus and Lüderitz Bay, S.W.A.	Aus/Lüderitzbucht	SMF 21085	2616 CA Garub	Identity questionable—see text. Rec. by FitzSimons (1962) as 2615 AD and by Broadley (1974) as 2615 CB but not mentioned in text. No accurate locality given by Mertens (1971), assumed to have come from Pro-Namib near Aus.
Gaitsabis, Mariental dist., S.W.A.		SM R1640	2417 DA Dassiesfontein	Rec. in text by Broadley (1974) but not on distr. map. <i>N. n. nigricincta/woodi</i> intergrade
Hardap Dam, Mariental dist., S.W.A.		TM 36603	2417 BD Hardap	Rec. by Broadley (1974) as <i>N. n. nigricincta. N. n. nigricincta/woodi</i> intergrade
Voigtshub, Mariental dist., S.W.A.		TM 52154	2417 BA Kalkrand	Coll. O. Chatwind don. Dec. 1978. New distr. rec. <i>N. n. nigricincta/woodi</i> intergrade
Moorivier, Maltahöhe dist., S.W.A.		TM 39962 TM 48166	2416 CA Donker Gange	Rec. by Broadley (1974). TM 48166 coll. D. H. Truter 19/v/1976 re-confirms the record. <i>N. n. nigricincta/woodi</i> intergrade
Kuiseb Riv. betw. Gobabeb and Natab, Namib Desert Park, S.W.A.		TM 37183	2315 CA	Rec. by Broadley (1974) <i>N. n. nigricincta/woodi</i> intergrade
Gobabeb, Namib Desert Park, S.W.A.		TM 30172 TM 36881 TM 52155 NDRS R125 NDRS R126 NDRS R127	2315 CA	TM specimens 30172, 36881 rec. by Broadley (1974) All specimens <i>N. n. nigricincta/woodi</i> intergrades.
Rostock, Windhoek dist., S.W.A.		TM 30462	2315 BD	Rec. by Broadley (1974) <i>N. n. nigricincta/woodi</i> intergrade
Kraaipoot, Karibib dist., S.W.A.		TM 49786	2315 BB	Coll. W. D. Haacke 6/v/1976. New distr. rec. <i>N. n. nigricincta/woodi</i> intergrade
Onanesberg, Namib Desert Park, S.W.A.		NDRS R124	2215 DC	Coll. C. T. Stuart 24/ii/1974. New distr. rec. <i>N. n. nigricincta/woodi</i> intergrade
Rössing Mtn., Swakopmund dist., S.W.A.		TM 50675	2214 DB	Coll. J. A. van Rooyen 16/i/1978. New distr. rec. <i>N. n. nigricincta/woodi</i> intergrade





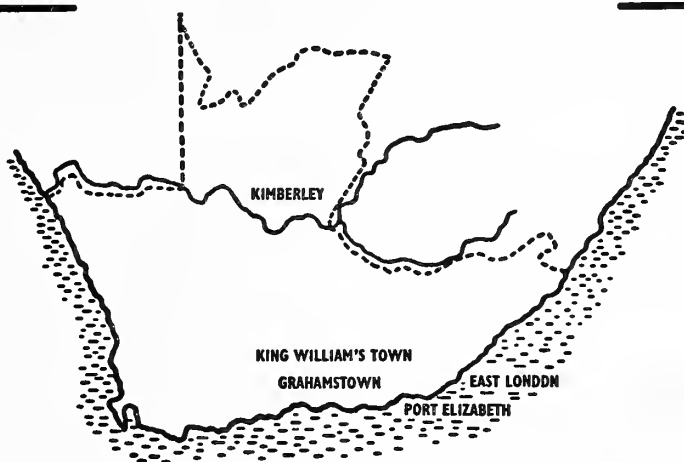


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# ANNALS OF THE CAPE PROVINCIAL MUSEUMS

NATURAL HISTORY

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A new species of *Megerlina* (Brachiopoda) from the Pleistocene of Zululand, South Africa

by

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Department of Geology, Rhodes University, Grahamstown 6140, South Africa  
(with 3 figures)

ABSTRACT

A new fossil species of the Terebratulacean brachiopod, *Megerlina*, is described from late Pleistocene limestones in the False Bay area of Lake St Lucia, Zululand. It is designated *Megerlina levis* **sp. nov.**

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INTRODUCTION

The present specimens were collected by Dr D. K. Hobday who sent them to the author for identification. They occurred, in local concentrations, within limestones of late Pleistocene (Eemian) age exposed in small outcrops at Lister's Point and Picnic Point on the western shores of the False Bay area of the Lake St Lucia lagoonal complex on the Zululand coastal plain (Fig. 1). Associated with the brachiopods were a variety of corals, gastropods, bivalves and cirripeds as well as echinoderm and sponge fragments and possible crab remains. Vertical tubes with horizontal branches of the ichnogenera *Thalassinoides* and *Ophiomorpha* were also present. The overall fauna and lithology of the enclosing sediments indicate an unrestricted, high energy, shallow marine environment not far from shore, with water temperatures slightly warmer than at present (Hobday, 1976: 103–105).

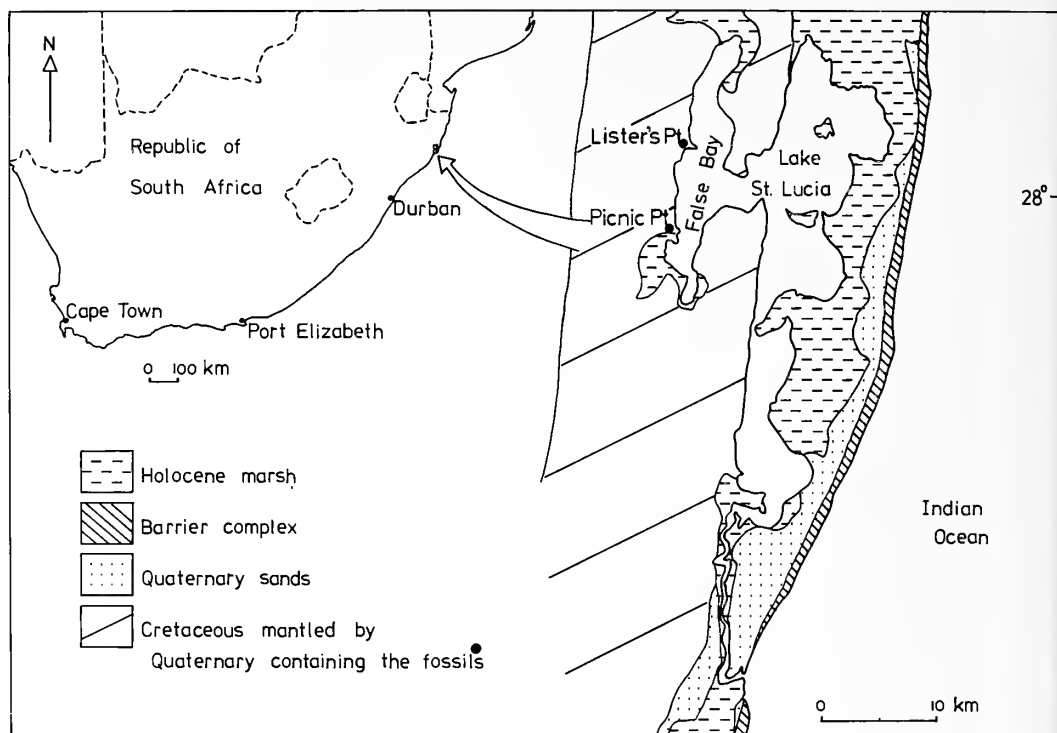


Fig. 1. Map showing location and geology of the Lake St Lucia lagoonal complex (After Hobday 1976).

## SYSTEMATIC DESCRIPTION

### Class ARTICULATA

#### Superfamily Terebratulacea King, 1850

#### Family Kraussinidae Dall, 1870

#### Genus *Megerlina* Eudes-Deslongchamps, 1884

Type-species: *Kraussia lamarckiana* Davidson, 1852: 80 by original designation.

#### *Megerlina levis* sp. nov. (Figs. 2, 3)

#### Type material

Holotype:	AM-4778
Paratype 1:	AM-4779
Paratype 2:	AM-4780
Paratype 3:	AM-4781

The specimens are housed in the Albany Museum, Grahamstown, South Africa.

*Diagnosis*

Subpentagonal *Megerlina* with carinate pedicle valve and sulcate brachial valve, and lacking any radial ornamentation.

*Material and horizon*

Fourteen pairs of conjoined valves and fragments of several other pedicle and brachial valves from late Pleistocene deposits on the Zululand coast.

*Description*

Small ventribiconvex shells of subpentagonal to transversely subcircular outline; maximum width about midvalve; hinge-line width about three-quarters of maximum width; postero-lateral margins (beak ridges) straight, subtending an angle of about  $120^\circ$  at the umbo. Pedicle valve over nine-tenths as long as wide and just over one-third as deep as long. Lateral profile evenly convex; anterior profile convex with narrow, round-topped median fold extending from umbo and separating flat to very gently convex flanks; profile of younger forms more evenly convex, fold not as pronounced. Umbo suberect; pedicle opening submesothyridid. Small, but conspicuous, triangular palintropes developed on either side of delthyrium; deltidial plates narrow.

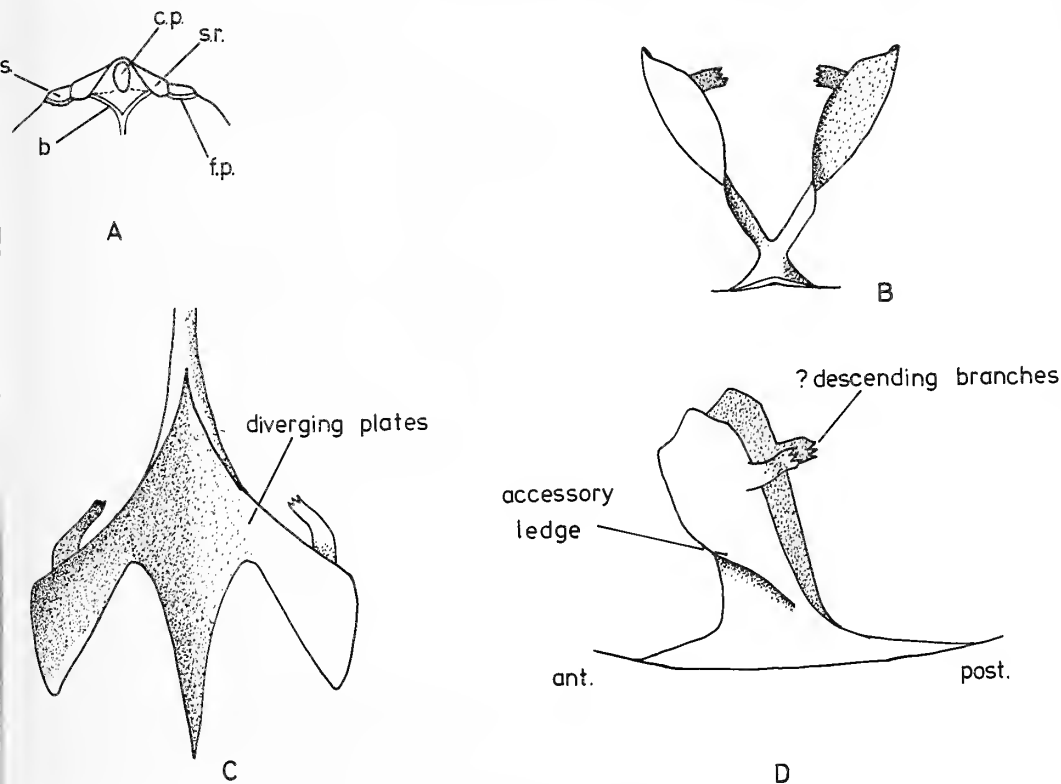


Fig. 2. A. Diagram of the cardinalia of *Megerlina levis* sp. nov. b—buttress; c.p.—cardinal process; f.p.—fulcral plate; s—socket; s.r.—socket ridge; About 5.5 times natural size. B. C. D. Posterior, ventral and lateral views of brachidium. About 12 times natural size.

Brachial valve about four-fifths as long as wide and a little over one-fifth as deep as long. Lateral profile gently convex with maximum convexity near umbo; anterior profile gently convex but with narrow median sulcus which arises at 2 mm growth stage and expands and deepens gradually towards anterior margin. Sulcus of young forms shallower than in adults. Ornamentation of faint concentric growth lines and single prominent growth lamella near anterior margin of some specimens; otherwise shells are smooth. Punctae well seen over whole of shell surface, with density of 120–180 per sq. mm.

Ventral interior with stout hinge teeth without supporting dental plates; pedicle collar very slightly excavate anteriorly. Dorsal interior largely obscured by infilling sediment but one specimen shows weakly developed, elliptical, knob-like cardinal process between strong, widely divergent socket ridges. These are buttressed on their inner sides by a pair of short plates which converge on to valve floor to define notothyrial cavity (Fig. 2A). About mid-valve a low median septum supports a pair of anteroventrally directed diverging plates, which are slightly concave towards one another; each bears a blunt point at the distal end which reaches almost to the floor of the opposite valve and a curved accessory ledge is present on the outside of each plate. From about two-thirds to three-quarters the way up the posterior edge of each plate, a slightly curved prong protrudes (Fig. 2B-D). These prongs have been interpreted as elements of a rudimentary transverse band in the case of the closely related genus *Kraussina* (Elliot 1949: 541) but Thomson (1927: 225), Jackson (1952: 30) and Cooper (1973: 22) think they represent the anterior ends of the descending branches of a loop. However, the posterior ends of such branches have not been described. Details of the musculature are obscured.

#### Dimensions

		length	width
Holotype:	pair of conjoined valves	13,5 mm	15,3 mm
Paratype 1:	pair of conjoined valves	12,2 mm	13,2 mm
Paratype 2:	fragment of brachial valve	—	—
Paratype 3:	fragment of conjoined valves	—	—

#### Discussion

The present specimens of *Megerlina* can immediately be distinguished from *M. lamarckiana* (Davidson), from the shallow waters around the south-east coast of Australia, *M. davidsoni* (Vélain) from St Paul Island, and from *M. capensis* (Adams & Reeve) and *M. striata* Jackson, both of which occur off the south-west coast of Cape Province. These modern forms are all distinctly ribbed, although this ribbing may develop upon a smooth early growth stage. Another form which occurs off the South African coast is *M. pisum* (Lamarck) which is described by Jackson (1952: 30) as being nearly smooth but with faint traces of costation; the new species shows no traces of costation and can be further distinguished by its narrower, deeper sulcus. Jackson (1952: 33) ends his discussion of *M. pisum* by noting that the internal characters of the type specimens from Mauritius were unknown to him and that his description was based on South African specimens which he identified by their outward appearance only. He states that if further specimens from Mauritius should prove to differ in their cardinalia and brachidium then the South African shells should be known as *M. natalensis*. However, Cooper (1973: 22) described a *M. natalensis* (Krauss) from the south-east coast of Cape Province, a locality also quoted by Jackson for his *M. pisum*.

In synonymy with *M. natalensis*, Cooper places *Terebratula natalensis* Krauss 1844 and *Terebratula algoensis* Sowerby 1847, two forms which are also included in the synonymy list given by Jackson for *M. pisum*. There appears to be a certain amount of confusion over the identity of these two forms but the shells described by Cooper are quite distinctly ribbed and must be separate from *M. pisum* as well as the specimens described herein.



Smith (1901: 116) records *Kraussina atkinsoni* (Woods) from Algoa Bay but Jackson (1952: 32, 33) regards the specimens as juvenile forms of *M. pisum*, an identification he also gives to a small, smooth sulcate shell with strong growth lamellae, that was dredged off Durban and originally identified as *K. atkinsoni* by G. B. Sowerby. The superficial resemblance of these juvenile forms to *Megerlina levis* sp. nov. tempts one to speculate that the Zululand species may be ancestral to *M. pisum*.

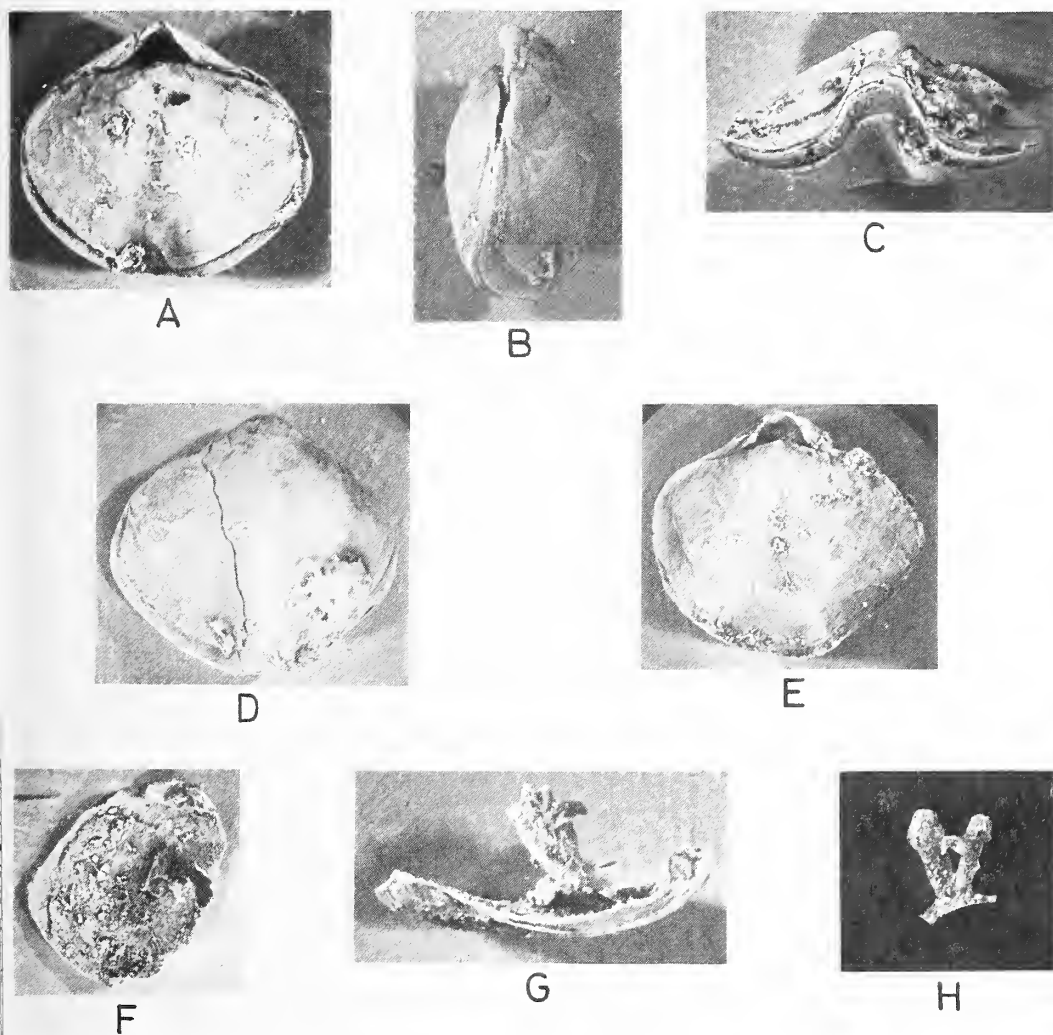


Fig. 3. *Megerlina levis* sp. nov. A, B, C, D. Dorsal, lateral, anterior and ventral views of conjoined valves, Holotype (AM-4778). Respectively  $\times 2.5$ ,  $\times 2.7$ ,  $\times 2.8$ ,  $\times 2.5$ . E. Dorsal view of conjoined valves, (AM-4779)  $\times 2.7$ . F, G. Ventral and lateral views of a broken brachial valve interior, (AM-4780). Respectively  $\times 2.7$ ,  $\times 4.1$ . H. Posterolateral view of brachidium, (AM-4781)  $\times 2.2$ .

In discussing the generic position of *K. atkinsoni*, Jackson (1952: 32, 33) says that he does not consider it a true *Kraussina* and that it should be removed from that genus. Although it resembled *M. lamarckiana*, Jackson was doubtful whether the species should be included in *Megerlina* without further investigation. However, Hatai (1965: H834) gives the time range for *Megerlina* as Neogene (Tasmania)–Recent and the type specimens of *K. atkinsoni* are from Miocene deposits in southern Tasmania. Thus it seems that *K. atkinsoni* has indeed been transferred to *Megerlina* and, apart from the present specimens, is the only other fossil form of the genus so far recorded. It is a ribbed form and is therefore distinct from *M. levis* sp. nov.

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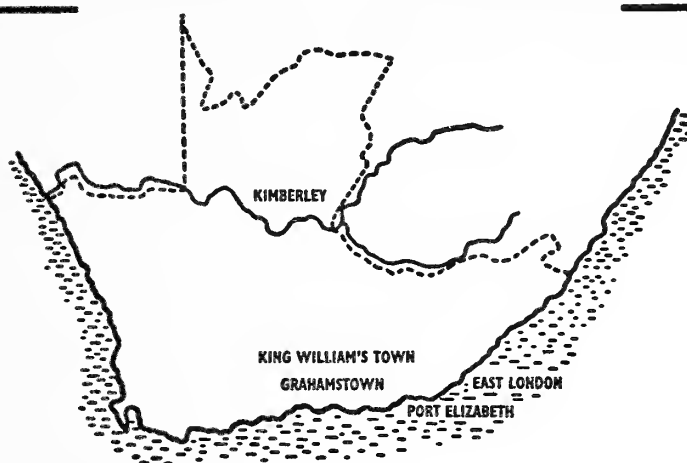
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# Ethological notes on *Kohliella alaris* Brauns (Hymenoptera: Sphecidae: Larrinae) in the Eastern Cape Province of South Africa

by

F. W. GESS

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and

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## INTRODUCTION

The genus *Kohliella* Brauns, 1910 is endemic to southern Africa and includes two species poorly represented in collections.

*Kohliella alaris* Brauns, the type species, black and ranging in length from 6–11 mm, was described from Willowmore (Cape Province) (Brauns, 1910: 669) and was subsequently recorded from Hex River (Cape Province) and Bulawayo (Zimbabwe) (Arnold, 1924: 43) and from two localities on the Cape Peninsula (Beaumont, 1967: 510). In the Albany Museum collection it is represented by specimens collected by the authors at New Year's Dam, Alicedale and on Hilton, Grahamstown (both Cape Province). *K. stevensoni* Arnold, the second species, was described from Sawmills (Zimbabwe) (Arnold, 1924: 42).

It has been pointed out by Bohart and Menke (1976: 286) that, although *Kohliella* is similar to *Tachysphex* in general facies, only a few features such as the form of the collar, the male forefemoral notch, and the bare pygidial plate are common to both, and that *Kohliella* is probably best regarded as a specialized relic.

Nothing has hitherto been published regarding the biology of the genus.

The present paper is the sixth of a series of publications dealing with the ethology of certain solitary wasps occurring at Hilton, a farm situated 18 kilometres WNW. of Grahamstown (33° 19'S, 26° 32'E) in the Albany Division of the Eastern Cape Province of South Africa. An account of the climate and vegetation of Hilton has previously been given (Gess and Gess, 1974: 191–192).

## THE NESTING OF KOHLIELLA ALARIS BRAUNS

### *Description of the nesting sites*

At Hilton *Kohliella alaris* nests in sand on the floor of a sandpit and in close proximity to the sandpit in places where the vegetation has been removed leaving the sand bare or with very sparse plant cover (Figs 1 and 2). The sand, light coloured and fine grained, is derived from the weathering of Witteberg Quartzite and is of alluvial origin having been deposited upon its flood plain by a seasonal tributary of the New Year's River. *K. alaris* tends to nest in pseudo-colonies making use of only small areas within nesting sites which appear to offer suitable conditions for nesting throughout.



Fig. 1. Hilton, 12.i.1978. Portion of sand pit with figure marking a nesting site of *Kohliella alaris*.



Fig. 2. Hilton, 12.i.1978. Entrance to a nest of *Kohliella alaris* in nesting site shown in Fig. 1.

### Flight period

Males and females of *K. alaris* have been collected at Hilton from early December to early March and nesting takes place throughout this period. During the summer of 1977-78, which was a particularly successful season for this species, nesting was at its height in mid-January.

Whereas most of the sphecids nesting in the sandpit commence their daily nesting activities before the hottest time of day and continue them into the early afternoon or on the hottest days cease activity before noon, *K. alaris* never appears before noon and rather commences its activities after noon, when the heat of the day is past its peak, and on the hottest days may delay its nesting activities until as late as 4.15 p.m., with the peak of nesting activity half an hour later.

Males are present in the nesting area and have been seen to attempt to mate with females in close proximity to the nests.

### Plants visited by adult wasps

There are no records of *K. alaris* visiting plants. However, trees and shrubs must be visited by the females when hunting for it is in such situations that the prey occurs. It is probable that the wasps visit a belt of shrubs and small trees which occurs along the banks of the seasonal tributary near the sandpit. Although *K. alaris* was not observed in this situation, both males and females were caught in a Malaise trap erected between shrubs on the edge of this belt.

### Identification of the prey

Twenty-six prey were recovered from *K. alaris* or its nests and without exception were nymphs of the Tree Cricket *Oecanthus capensis* Saussure (Gryllidae: Oecanthinae). Adult *O. capensis* in the Albany Museum were collected at Brak Kloof, a farm adjoining Hilton, during the months February to April.

Details of the prey and of their captors are given in Tables 1 and 2. It will be seen that the prey is mutilated by the wasp in that the antennae are cut off short (Fig. 3). Mutilation must take place immediately after prey capture as prey being transported to the nest are already in the "dressed" condition.



Fig. 3. Contents of the cell of nest 11 (see Table 1) consisting of three tree crickets, *Oecanthus capensis*, the third from the left bearing the egg of the nest builder shown on right. (x 2,8)

TABLE 1. Details pertaining to *Kohliella alaris* females, their prey and eggs associated in nests.

Date	Nest no.	Cell no.	Cell contents: prey in order of introduction into cell (where known), prey bearing <i>K. alaris</i> egg.	Prey weight (mg)	Prey length (mm)	Mutilations to prey	Wasp weight (mg)	Wasp length (mm)
13.i.78	1	1	(1) male nymph (with egg)	28	11,5	Both antennae shortened Left hind leg missing	—	—
			(2) female nymph	31	13,0	Both antennae shortened		
13.i.78	3	1	(1) male nymph (with egg)	36	12,0	Both antennae shortened Left hind leg missing	22	10,0
13.i.78	4	1	(1) female nymph	26	11,0	Both antennae shortened	—	—
13.i.78	6	1	(?) female nymph (with egg)	31	13,5	Both antennae shortened	22	10,0
			(?) male nymph	14	9,2	Both antennae shortened		
		2	(1) male nymph	44	14,0	Both antennae shortened		
17.i.78	7	1	(?) male nymph	5	6,2	Both antennae shortened	—	—
			(?) male nymph	4,5	6,0	Both antennae shortened		
			(?) male nymph	7,0	8,0	Both antennae shortened Right hind leg missing		
			(4) male nymph (with egg)	37	14,0	Both antennae shortened Right hind leg missing		
17.i.78	8	1	(1) male nymph	31	12,5	Both antennae shortened	25	10,0
18.i.78	10	1	(?) male nymph	20	11,8	Both antennae shortened	24	10,0
			(2) male nymph (with egg)	29	11,3	Both antennae shortened		
			(?) female nymph	50	15,8	Both antennae shortened Right hind leg missing		
9.ii.78	11	1	(?) female nymph	13	8,8	Both antennae shortened	—	—
			(2) female nymph (with egg)	29	11,3	Both antennae shortened		
			(?) male nymph	29	12,0	Both antennae shortened		
3.iii.78	14	1	(1) female nymph (with egg)	45	14,5	Both antennae shortened	—	—
			(2) female nymph	31	13,2	Both antennae shortened		



GESS & GESS: NOTES ON KOHLIELLA ALARIS BRAUNS

TABLE 2. Details pertaining to *Kohliella alaris* females and their prey associated during prey transport.

Date	Prey sex & developmental stage	Prey weight (mg)	Prey length (mm)	Mutilations to prey	Wasp weight (mg)	Wasp length (mm)
16.ii.76	female nymph	43	12,5	Both antennae shortened	18	9,3
16.ii.76	male nymph	21	8,3	Both antennae shortened	24	9,5
9.xii.77	male nymph	—	11,0	Both antennae shortened	—	—
20.xii.77	— nymph	—	6,3	Both antennae shortened	—	10,0
17.i.78	female nymph	46	14,5	Both antennae shortened	—	c.10
17.i.78	male nymph	26	11,0	Both antennae shortened Right hind leg missing	25	10,0

*Description of the nest* (Figs 4a and b, 5a and b)

The nest of *K. alaris* consists of a short trench, approximately 10 mm long, leading to a subcircular entrance hole, slightly wider than high, average width 4,3 mm (sample of 12), from which a shallow entrance passage of similar diameter extends from 20–35 mm (sample of 9) and reaches an average depth of 13 mm (sample of 7) below the surface of the ground. From this shallow burrow one to several secondary branches of a steeper gradient lead off, some of which end in a more or less horizontal single cell at an average depth of 35 mm (range 16–70 mm, sample of 15). Some passages appear to remain unused and are free from sand whereas the passages which end in a cell are filled with loose sand. A secondary passage may be excavated in the same direction as the entrance passage or it may make a sharply acute to obtuse angle with it. Similarly, a cell may have its long axis following the same direction as the secondary passage or it may be at an angle to it. Such secondary passages which terminate in a cell are 15–60 mm long (sample of 11) and 4–5 mm in diameter and the cells have an average length of 16 mm (sample of 8) and an average diameter of 6,6 mm (sample of 9), therefore being of a slightly larger bore than that of the secondary passages.

*Method of construction of the nest, provisioning and oviposition*

*K. alaris* is a sand raker. After the wasp has selected a nesting site, nest construction is immediately initiated by her digging and raking away the soil. When the sand which is excavated in the construction of the nest begins to accumulate forming a pile, the wasp spreads it from side to side using a light dancing motion. Any particles which are too big to be extracted from the excavation by raking are carried out by the wasp in her mandibles. At the start of nest excavation the wasp is easily distracted by passing insects such as ants but makes no attempt to chase them. However, as nest construction becomes more advanced she becomes more determined and aggressive making attempts to drive away passing insects.

Hunting takes place after a cell has been excavated and the nest temporarily sealed with sand. The wasp having located, captured, stung and mutilated her prey she flies with it to the nest holding it beneath her with its head facing the direction of travel. She alights close to the

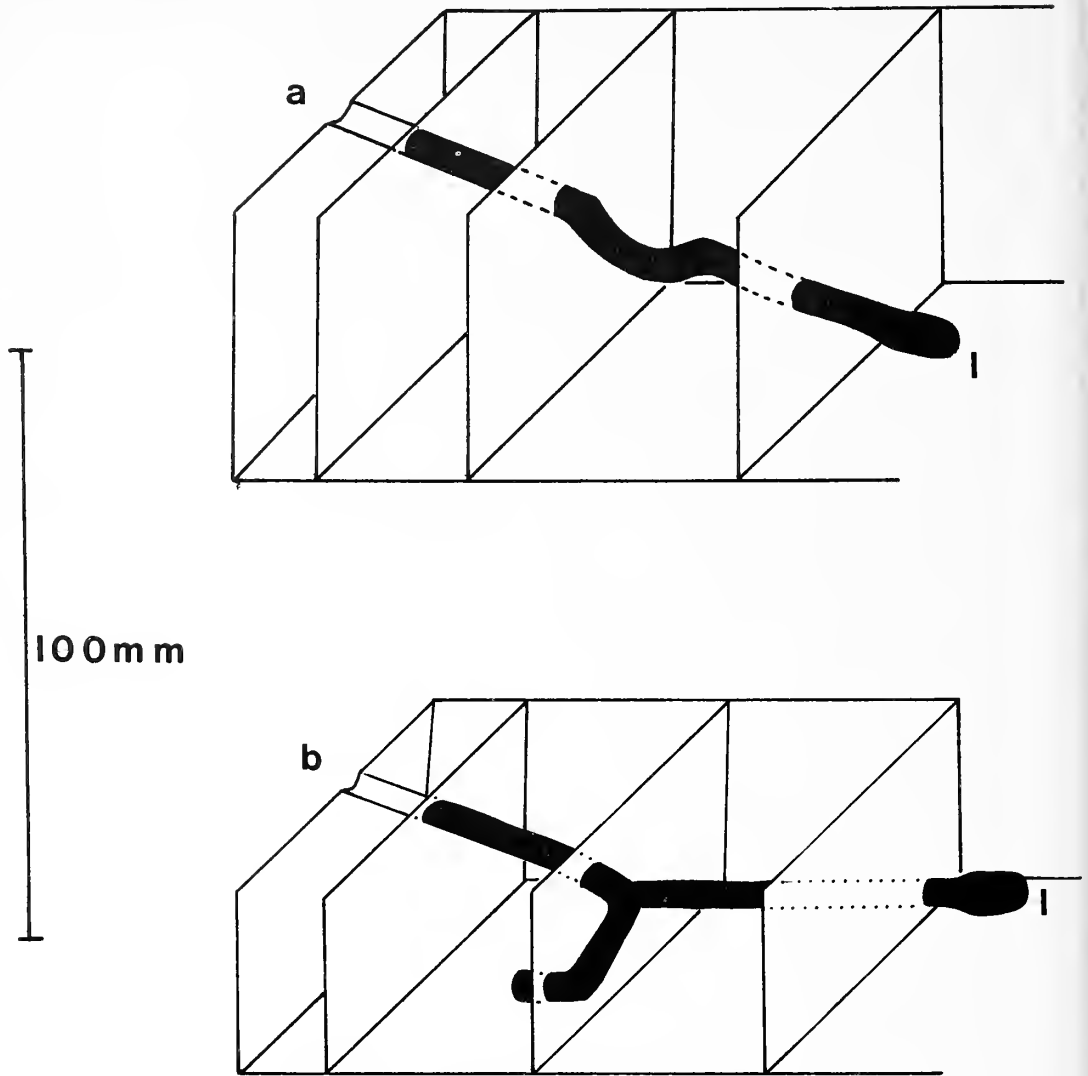


Fig. 4a and b. Plans of nests 8 and 3 of *Kohliella alaris*.

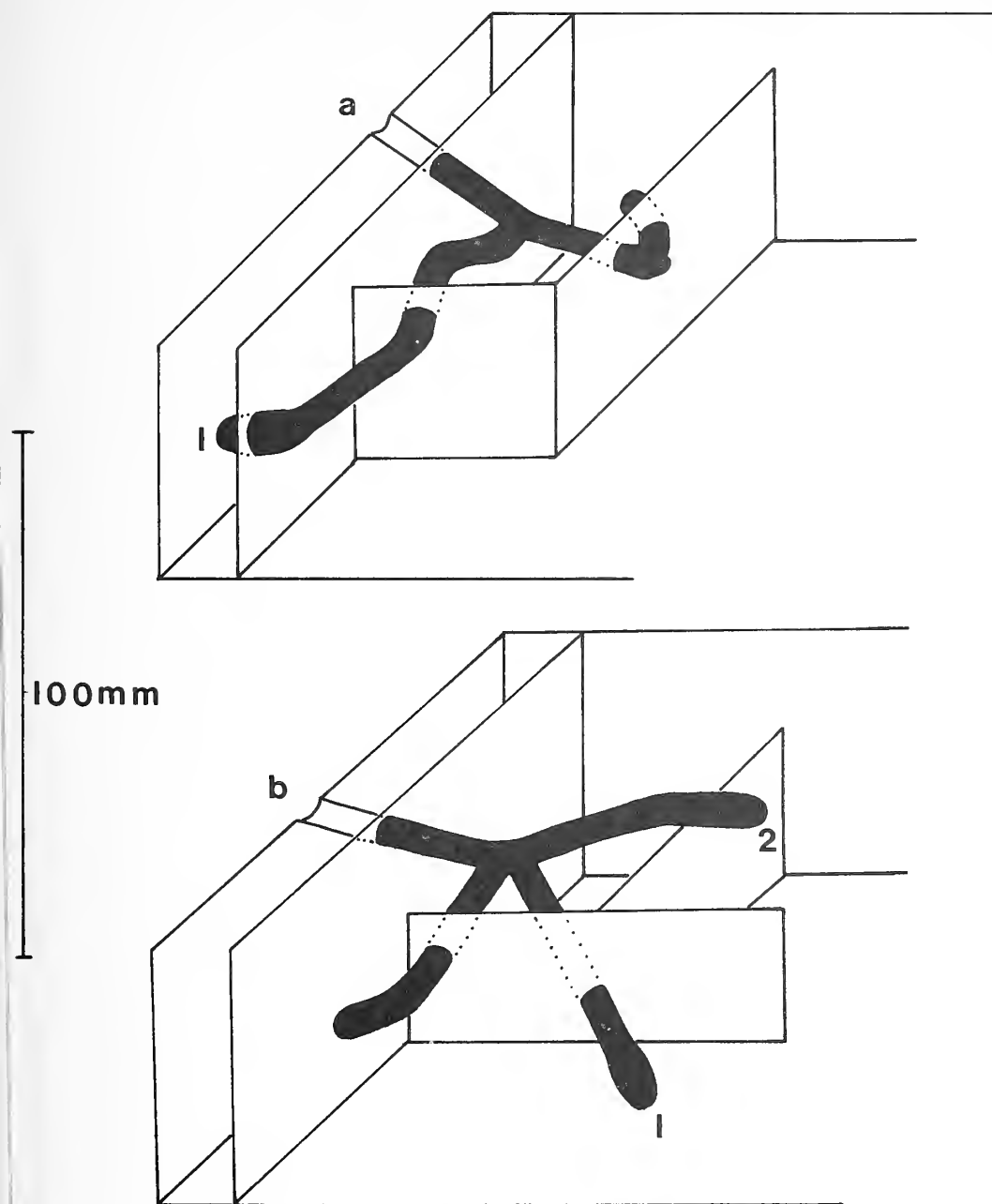


Fig. 5a and b. Plans of nests 1 and 7 of *Kohliella alaris*.

entrance to the nest, puts down the prey, rakes the sand out of the nest entrance, enters, turns around within, and draws the prey in head first.

Fourteen nests were excavated from which the contents of ten provisioned or partially provisioned cells were obtained (see Table 1) and were found to consist of twenty prey, seven of which bore wasp eggs. In a cell several prey are positioned venter up facing the inner end of the cell and parallel to each other but with every prey slightly in advance of that succeeding it. The prey are incompletely paralysed and exhibit occasional trembling movements of the palps and continuous pumping respiratory movements of the abdomen.

The egg of *K. alaris* is slightly curved, pearly white and 2,6 mm long (average of 5) and 0,5 mm wide at its mid length. It is attached by its anterior end to the underside of the prothorax of one of the prey, posterior to either the right or left prothoracic coxa, and extends transversely across the venter of the prey (Fig. 3). For six of the eggs it was possible to establish the order of introduction into the cell of the prey to which they were attached. Three eggs were on the first prey, two on the second prey and one was on the fourth prey. In the instance of the fourth prey being selected for oviposition it was the only one of any considerable size weighing 37 mg whereas the first three weighed only 5, 4,5 and 7,0 mg respectively. It is therefore likely that if the first prey to be captured are very small oviposition is postponed until one of a suitable size is obtained.

The secondary passage leading to a cell is usually filled with loose sand whereas the entrance passage is left clear. When leaving the nest the wasp closes the entrance. She stands inside the burrow and rakes sand in towards herself and through underneath to behind herself, gradually advancing out of the nest. When only a small depression is left she rakes sand over it from all directions until it is completely obscured. Three nests which had been seen to be closed in this way were excavated and were found to have as yet incompletely provisioned cells. It is therefore clear that the wasp closes her nest between visits.

#### *Parasites*

Five miltogrammine sarcophagids were reared from maggot infested prey recovered from a cell excavated on 18.i.1978. The flies emerged from their puparia on 6.ii.1978.

### DISCUSSION

*Kohliella* with *Parapiagetia*, *Holotachysphex* and *Prosopigastra* may be grouped around *Tachysphex*, one of the dominant sphecids genera and one of the most highly evolved members of the tribe Larrini (Bohart and Menke, 1976: 269). As these five genera together form a distinct evolutionary branch within the subtribe Tachytina and as nothing has hitherto been published concerning the biology of *Kohliella* it is of interest to compare the five genera with respect to various aspects of nesting ethology.

A considerable number of papers on the biology of *Tachysphex* species have appeared, important ones being listed by Bohart and Menke (1976: 270). A useful summary of the known biology of the Palaearctic species has been provided by Pulawski (1971: 16–20). In contrast little has been published on the biology of *Prosopigastra* and almost nothing on that of *Parapiagetia*. For both genera the known biology has been reviewed by Bohart and Menke (1976: 285 and 281 respectively) and for *Prosopigastra* additional data have been presented by Pulawski (1979) who has also summarized the life history of the genus. An account of the nesting of a species of *Holotachysphex*, *H. turneri* (Arnold) in trap-nests has been published by Gess (1978: 209–215). In addition, since the publication of this account, natural nests of *H. turneri* have been found by the authors at Hilton in old abandoned galleries of the carpenter bee, *Xylocopa caffrariae* Enderlein in the hollow internodes of dry culms of *Phragmites australis*, a reed fringing permanent and semi-permanent water bodies.

The nests of *Kohliella* like those of *Tachysphex* and *Prosopigastra* are situated in the ground, in friable soil; however, *Holotachysphex* by contrast nests up off the ground in hollow plant stems. The nests of *Parapiagetia* have not as yet been located but the presence in the female of fore-tarsal sand rakes and of a pygidial plate indicates that this genus like *Kohliella* is ground nesting.

*Kohliella* like almost all species of *Tachysphex* excavates its nest itself whereas *Prosopigastra*, *Holotachysphex* and the exceptional species of *Tachysphex* modify pre-existing cavities, frequently the galleries of other aculeate Hymenoptera.

The nests of *Kohliella* that were investigated were all still under construction; eight contained a single provisioned or partially provisioned cell and one contained two cells. It is therefore not known whether the number of cells constructed ever exceeds two. *Tachysphex* nests may be one- or two-celled or multicellular, those of *Prosopigastra* are multicellular and *Holotachysphex turneri* nests have been found with one, two and three cells. Thus it appears that all four genera show a tendency to construct more than one cell per nest.

*Kohliella* unlike *Prosopigastra* and *Holotachysphex* which leave the nest entrance open during provisioning maintains a temporary closure during this period. *Tachysphex* displays variability in its behaviour in this respect. As *Kohliella* maintains a temporary closure it may be assumed that like *Tachysphex*, *Prosopigastra* and *Holotachysphex* it constructs a final closure.

*Kohliella* like *Holotachysphex*, *Parapiagetia* and some species of *Tachysphex* preys upon Orthoptera. Other species of *Tachysphex*, however, prey upon Dictyoptera and *Prosopigastra* preys upon Hemiptera. In all genera nymphs are generally taken. The report that an unknown *Parapiagetia* species was seen transporting a caterpillar should, it is considered, be treated with great caution.

*Kohliella* like *Tachysphex* transports its prey held beneath its body and facing the direction of travel. *Kohliella*, *Tachysphex* and *Prosopigastra* are known to carry their prey in flight and judging from the small size of its prey and the situation of its nest *Holotachysphex* probably also transports its prey in flight. When the prey is large and heavy relative to the wasp, *Tachysphex* is known to transport it along the ground in short hopping flights.

*Kohliella* like some species of *Tachysphex* deposits the prey on the ground at the nest entrance, opens and enters the nest, turns around within it and then draws in the prey unlike *Prosopigastra* and some other species of *Tachysphex* which enter the nest directly.

*Kohliella* like *Holotachysphex* and *Prosopigastra* provisions each cell with several prey, however, *Tachysphex* when large prey are taken may provision with a single prey. In all four genera paralysis of the prey is incomplete. *Kohliella* like *Holotachysphex* and those *Tachysphex* species which provision their nests with Acrididae positions its egg attached immediately posterior to one of the prothoracic coxae and extending transversely across the venter of the prey.

From the above comparison of various aspects of the nesting ethology of the five genera it is evident that the latter form a fairly close-knit group. *Tachysphex*, the species-rich dominant genus around which the other genera are grouped shows a considerable ethological latitude or plasticity whereas the ethology of the other genera appears more circumscribed. However, this is likely to be merely an expression of the fact that the other genera have far fewer species and that data concerning these are limited. Among those ethological aspects considered *Kohliella* does not manifest any character which is unique to itself and which is not found also in the genus *Tachysphex* seen as a whole (though of course if compared with individual species of *Tachysphex* various differences do become apparent). On the other hand the ethology of *Kohliella* differs in several aspects from that of both *Holotachysphex* and *Prosopigastra*. (Not enough is known of the ethology of *Parapiagetia* to allow comparison.) Ethologically *Kohliella* therefore has the greatest affinity with *Tachysphex*, the affinity being greater than that shown by either *Holotachysphex* or *Prosopigastra* with that genus.

# SUMMARY

Some aspects of the ethology of *Kohliella alaris* Brauns (Hymenoptera: Sphecidae: Larrinae) in the Eastern Cape Province of South Africa are described. In the study which was based upon a series of nests excavated in sand attention is given to the description of the nesting sites, flight period, plants visited by adult wasps, identification of the prey, description of the nest and method of its construction, provisioning and oviposition. The nesting of *Kohliella* is compared with that of the genera *Parapiagetia*, *Holotachysphex*, *Prosopigastra* and *Tachysphex* and is found to be very similar to that of the last named.

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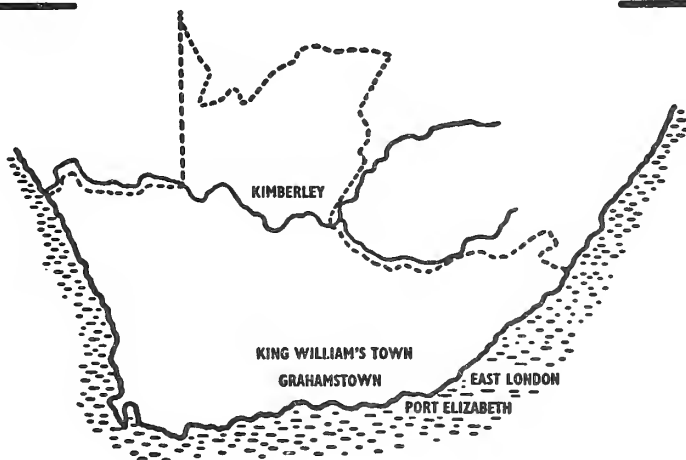
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## A new species of *Lemniscomys* (Muridae) from Zambia

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### ABSTRACT

A new species of *Lemniscomys*, *L. roseveari* sp. nov. is described and the status of the components of the *L. griselda* species-complex is examined by statistical analyses.

### INTRODUCTION

During an overall revision of the species-group *Lemniscomys griselda* the author had the opportunity of examining an important series of a "single-striped grass mouse" collected in Balovale, Northern Rhodesia (now Zambia) by G. C. Shortridge and T. D. Carter in 1938.

The conclusion that this "grass mouse" belongs to an undescribed species was the result of an extensive statistical analysis, using canonical analysis and discriminant analysis (see Van der Straeten & Van der Straeten-Harrie, 1977, and Van der Straeten & Verheyen, 1978).

The author is very pleased to name the mouse *Lemniscomys roseveari* sp. nov. in honour of D. R. Rosevear whose book *The Rodents of West Africa* was a great stimulus and help when he started his studies on African Muridae.

A complete discussion of the *Lemniscomys griselda* species-group will be the subject of a later publication.

### DESCRIPTION OF *LEMNISCOMYS ROSEVEARI* SP. NOV.

Measurements in mm of adult *Lemniscomys roseveari* sp. nov. are given in Table 1.

General colour of the back brownish, anteriorly more greyish, posteriorly more yellow-ochre, most like *L. linulus* from the Ivory Coast. Well defined black mid-dorsal stripe commencing between the ears. Back with pale-tipped hairs (buff or ochraceous-buff) forming small spots; the spots not forming a well defined pattern. More brownish than *L. rosalia* (cf. *sabulata*) and *L. griselda* but a little paler than *L. rosalia* (cf. *spinalis*). Ears and feet with yellow-ochre hairs. The hairs of the underside are pure white; underside edged with a buff line. Tail longer than head and body, about 110% of the head and body length, dark above, ochraceous-orange or yellow-ochre laterally and white below. Mammary formula 2(2-2). Skull large with a broad  $M^1$ , supra orbital ridges well developed. Upper incisors mostly with faint grooves. Some specimens have a small  $Sm$  in  $M_7$ . The skull measurements of males and females show only small differences. The skull measurements, PAL, UPDE,  $M^1$ , BUL and BRCA are highly significantly larger (= 1% significance level) than, DIN and ROB are significantly larger (= 5% significance level) than, and PAF is highly significantly smaller than for the other members of the East and South African *Lemniscomys griselda* species-complex (see discriminant analysis). The hindfoot is significantly longer in males than in females.

TABLE 1.

Measurements in mm of adult *Lemniscomys roseveari*. Number of specimens measured, mean, range and standard deviation are given from left to right for each of the measurements. For the exact description of the skull-measurements see Van der Straeten & Van der Straeten-Harrie (1977).  
The external measurements are those shown on the museum labels.

Variable code	Description	Holotype	<i>Lemniscomys roseveari</i> ♂♂	<i>Lemniscomys roseveari</i> ♀♀
HB	Head and body length	137.0	15; 123.7 (113.0 - 137.0) 6.4	11; 125.7 (118.0 - 137.0) 5.7
TL	Length of tail	147.0	14; 137.3 (123.0 - 151.0) 8.7	11; 138.7 (129.0 - 153.0) 7.2
HL	Length of hind foot	28.25	15; 28.3 (26.5 - 29.5) 0.7	11; 27.2 (26.0 - 28.5) 0.9
EL	Length of ear	17.0	15; 16.4 (16.0 - 18.0) 0.6	11; 16.2 (13.0 - 19.0) 1.4
GRLE	Greatest length of skull	33.90	17; 32.18 (30.65 - 33.90) 0.88	11; 32.22 (30.80 - 33.90) 1.07
PRCO	Prosthion-condylion	31.20	17; 29.54 (27.85 - 31.00) 0.79	11; 29.45 (27.95 - 31.20) 1.03
HEBA	Henselion-basion	26.35	17; 25.03 (23.55 - 26.35) 0.69	11; 24.91 (23.65 - 26.35) 0.89
HEPA	Henselion-palation	14.00	17; 13.50 (12.65 - 14.40) 0.45	11; 13.45 (12.80 - 14.15) 0.41
PAF	Length of palatal foramina	6.35	17; 5.92 (5.55 - 6.45) 0.28	11; 5.89 (5.25 - 6.35) 0.27
DIA1	Length of diastema	8.40	17; 7.55 (6.80 - 8.10) 0.30	11; 7.66 (6.95 - 8.40) 0.43
DIA2	Distance between the anterior border of the alveole of M1 and the edge of upper incisor	8.90	17; 8.17 (7.40 - 8.60) 0.31	11; 8.33 (7.75 - 8.95) 0.43
INT	Interorbital breadth	4.70	17; 4.75 (4.50 - 4.90) 0.13	11; 4.70 (4.15 - 4.95) 0.24
ZYG	Zygomatic breadth on the zygomatic process of the squamosum	15.25	17; 15.16 (14.35 - 15.80) 0.42	11; 15.29 (14.55 - 16.25) 0.53
PAL	Palate breadth between M1	2.65	17; 2.49 (2.20 - 2.85) 0.15	11; 2.55 (2.10 - 3.00) 0.27
UPTE	Length of upper cheekteeth	6.05	17; 6.09 (5.75 - 6.40) 0.19	11; 6.06 (5.70 - 6.35) 0.22
UPDE	Breadth of upper dental arch	7.20	17; 6.78 (6.50 - 7.00) 0.15	11; 6.90 (6.50 - 7.35) 0.28
M1	Breadth of M1	2.20	17; 2.12 (2.05 - 2.20) 0.06	11; 2.11 (2.00 - 2.20) 0.06
ZYPL	Breadth of zygomatic plate	4.65	17; 4.23 (3.80 - 4.65) 0.24	11; 4.22 (3.90 - 4.65) 0.22
BNAS	Greatest breadth of nasals	3.70	17; 3.61 (3.35 - 3.90) 0.16	11; 3.59 (3.35 - 4.05) 0.24
LOTE	Length of lower cheekteeth	13.35	17; 12.38 (11.30 - 13.40) 0.55	11; 12.51 (11.45 - 13.40) 0.67
CHOA	Breadth of choanae	5.75	17; 5.80 (5.55 - 6.10) 0.18	11; 5.84 (5.35 - 6.05) 0.20
BUL	Length of auditory bulla	1.55	17; 1.47 (1.25 - 1.80) 0.15	11; 1.60 (1.40 - 1.75) 0.11
BRCA	Braincase breadth	6.50	17; 6.17 (5.80 - 6.55) 0.23	11; 6.04 (5.80 - 6.60) 0.27
DIN	Depth of incisors	13.45	17; 13.24 (12.70 - 13.70) 0.29	11; 13.37 (12.85 - 14.00) 0.35
ROH	Rostrum height at anterior border of zygomatic plate	1.85	17; 1.73 (1.50 - 1.90) 0.12	11; 1.74 (1.50 - 1.90) 0.14
ROB	Rostrum breadth at anterior border of zygomatic plate	8.40	17; 8.29 (7.50 - 9.00) 0.33	11; 8.24 (7.60 - 8.85) 0.40
PCPA	Distance between the extreme points of processus condylicus and processus angularis	6.15	16; 5.91 (5.50 - 6.35) 0.22	9; 5.95 (5.65 - 6.40) 0.25
		11.40	15; 10.84 (10.15 - 11.45) 0.33	8; 10.91 (9.70 - 11.50) 0.60

*Specimens examined*

*Holotype*: adult ♀, age-class 3, skin and skull, RG. No. 6396, from Balovale, Zambia, 1 015 metres, obtained 27 September 1938 by G. C. Shortridge and T. D. Carter during the Vernay-Kaffrarian Museum Zambesi Expedition. Type specimen in the collections of the Kaffrarian Museum, King William's Town, Republic of South Africa.

*Paratypes*: 8 specimens. Kaffrarian Museum, RG. No. 6353, ♀, age-class 6, 19/8/1938; RG. No. 6355, ♂, age-class 2, 20/8/1938; RG. No. 6356, ♂, age-class 3, 21/8/1938; RG. No. 6360, ♂, age-class 3, 22/8/1938; RG. No. 6373, ♀, age-class 5, 4/9/1938; RG. No. 6387, ♂, age-class 3, 17/9/1938; R.G. No. 6391, ♂, age-class 4, 25/9/1938; British Museum Natural History, RG. No. 49.354, ♂, age-class 5, 1/9/1938.

All specimens from Balovale, Zambia, with skin and skull, collected by G. C. Shortridge and T. D. Carter.

For details concerning age-classes see Van der Straeten (1979).

*Other material examined*: 28 specimens. Kaffrarian Museum, RG. Nos.: 6352, 6369, 6377, 6378, 6381, 6385, 6386, 6389, 6394, 6397, 6402, 6404, 6415, 6416, 6418, 6420 (all ♂♂, all from Balovale); 6358, 6361, 6362, 6370, 6374, 6383, 6392, 6395, 6412, 6417 (all ♀♀, all from Balovale); British Museum Natural History, RG. No. 1937.1.4.108, ♀, from Balovale; RG. No. 55.1164, ♀, from Solwezi.

## DISTRIBUTION

*Lemniscomys roseveari* sp. nov. at the present time is known only from two localities in Zambia: Balovale (13° 33'S, 23°07'E) and Solwezi (12° 10'S, 26° 24'E).

## STATISTICAL ANALYSES

*Canonical analysis.*

For the canonical analysis 179 specimens from East and South Africa were used. These were divided into eight groups as indicated in Table 2. The specific names used in Table 2 for the different forms of the *Lemniscomys griselda* species-group are based upon a biometrical revision of this species group.

TABLE 2.

Grouping of 179 specimens of *Lemniscomys* from East and South Africa for purposes of canonical analysis.

Group No.	Species	Number of specimens
1	<i>Lemniscomys roseveari</i>	28
2	<i>Lemniscomys rosalia</i> (cf. <i>spinalis-zuluensis-sabiensis</i> ) ♂♂	34
3	<i>Lemniscomys rosalia</i> (cf. <i>spinalis-zuluensis-sabiensis</i> ) ♀♀	45
4	<i>Lemniscomys rosalia</i> (cf. <i>calidior</i> )	23
5	<i>Lemniscomys griselda</i>	18
6	<i>Lemniscomys rosalia</i> (cf. <i>sabulata</i> )	14
7	<i>Lemniscomys rosalia</i> (cf. <i>rosalia</i> )	8
8	<i>Lemniscomys rosalia</i> (cf. <i>maculosus-phaeotis</i> )	9

The analysis is based upon 18 skull measurements (see Table 3). There are seven canonical variates, only five of which are significantly different from zero. In Table 4 are given the eigenvalues of the canonical transformation and the importance of the different canonical variates. In Table 3 are given the eigenvectors of the 18 variables for the first three canonical variates. Using these eigenvectors a diagram was drawn. For each group the centre and the most extreme values of each cluster of points are indicated. Fig. 1 shows the graphical representation of the first and second canonical variates. The other canonical variates are not illustrated as they give no further information concerning the problem.

TABLE 3.

Eigenvectors of 18 variables for the first three canonical variates.

Variable code	1	2	3
GRLE	- 0,8632	0,5884	- 0,9461
PRCO	2,5536	- 1,9409	1,7076
HEBA	- 2,3949	1,7373	- 1,8240
HEPA	- 0,2616	- 0,0931	- 0,0034
PAF	- 2,3517	0,3968	0,8509
DIA1	- 1,6253	- 0,3303	2,6270
DIA2	2,9291	- 0,5666	- 0,6978
INT	0,9013	- 1,6658	0,2164
ZYG	0,0128	1,1459	1,7343
UPTE	- 1,6967	0,0369	1,1756
UPDE	0,7826	- 0,0420	- 2,9892
M1	4,6652	10,2576	3,9417
ZYPL	0,5395	- 0,3966	- 0,0048
BNAS	1,1364	0,2550	- 0,9504
LNAS	0,3861	- 0,1074	0,4877
LOTE	- 0,1950	- 0,0873	- 0,2200
BUL	0,3856	0,3351	- 0,1951
BRCA	0,5189	0,0111	- 0,7968

TABLE 4.

*Eigenvalues of the canonical transformation with test of significance.*

No.	Eigenvalue	Relative (%) importance	Chi-square	Degrees of freedom	Probability
1	47,455	41,5	518,568	126	1,000
2	27,952	24,5	339,170	102	1,000
3	19,147	16,8	212,575	80	1,000
4	11,091	9,7	116,624	60	0,999
5	4,039	3,5	54,643	42	0,910
6	3,203	2,8	29,348	26	0,705
7	1,366	1,2	8,987	12	0,295

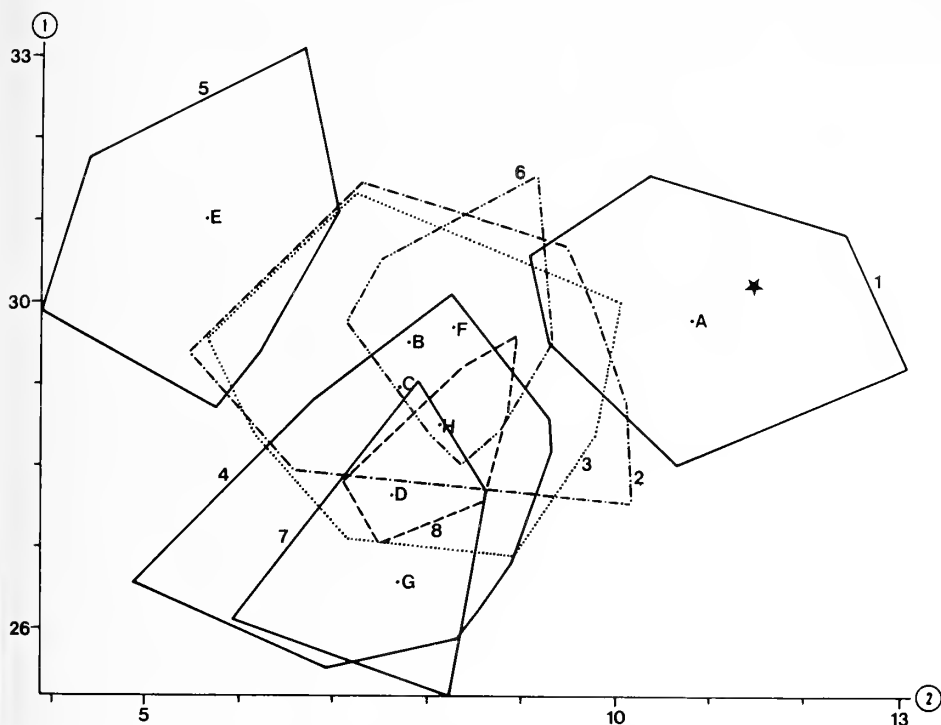


Fig. 1. Canonical analysis: canonical means (solid circles) and extreme limit of each cluster of points; canonical variates: 1 (abscis) and 2 (ordinate); 1, A: *Lemniscomys roseveari*; 2, B: *L. rosalia* (cf. *spinalis*) ♂♂; 3, C: *L. rosalia* (cf. *spinalis*) ♀♀; 4, D: *L. rosalia* (cf. *calidior*); 5, E: *L. griselda*; 6, F: *L. rosalia* (cf. *sabulata*); 7, G: *L. rosalia* (cf. *rosalia*); 8, H: *L. rosalia* (cf. *maculosus*); black star: type of *L. roseveari*.

Considering the first canonical variate there are distinguishable three groups within the East and South African *Lemniscomys griselda* species-complex: 1. *L. griselda*, 2. *L. rosalia* (with different subspecies separated by the second and third canonical variates) and 3. *L. roseveari*. The overlap between the three groups is very small. Each of these groups is considered here as corresponding with a valid species.

#### Discriminant analysis and dendrogram.

The same groups and specimens were used as for the canonical analysis with the addition, however, of a group of 113 specimens of *Lemniscomys linulus* (see Van der Straeten, 1979). Out of the 18 measurements used for the canonical analysis 11 were selected for the present analysis: GRLE, PRCO, HEBA, PAF, DIA2, INT, ZYG, UPTE, UPDE, M<sup>1</sup> and BUL. All groups were combined in a two by two groups discriminant analysis in order to determine the generalized distances of Mahalanobis ( $D_M^2$ ) and the probability of misclassification. The results are summarized in Table 5.

To illustrate the biometrical affinities a dendrogram was drawn up (Fig. 2) based on the matrix of  $D_M^2$  values and generated by the U.P.G.M.A. clustering method (see Sneath & Sokal, 1973).

The results of this dendrogram and those of the canonical analysis are almost the same. The West African *Lemniscomys linulus* is quite different from the East and South African species of the *Lemniscomys griselda* species-group. There is a very close relationship between *Lemniscomys rosalia* (cf. *spinalis*) (=spin in Fig. 2), *L. rosalia* (cf. *subulata*) (=sab), *L. rosalia* (cf. *calidior*) (=cal), *L. rosalia* (cf. *rosalia*) (=rosa) and *L. rosalia* (cf. *maculosus*) (=phae) which are considered to belong to the same species namely *Lemniscomys rosalia*. Further study of more material is needed, however. The biometrical distance between *Lemniscomys rosalia*, *L. griselda* and *L. roseveari* is important enough to consider these three forms as valid species.

TABLE 5.

Matrix of generalized distances of Mahalanobis (=  $D_M^2$ ) (lower triangle) and probability of misclassification (%) using a 11 variate discriminant function (upper triangle) (abbreviations see Fig. 2).

Species No. Specimens	lin 113	ros 28	spin 79	cal 23	gris 18	sab 14	rosa 8	phae 9
lin	—	0,00	0,01	0,19	0,00	0,00	0,08	0,00
ros	90,0530	—	6,08	2,38	0,21	4,78	0,40	0,17
spin	53,7478	9,5844	—	18,42	5,13	30,25	2,71	13,82
cal	33,4167	15,6836	3,2364	—	1,25	8,37	14,74	5,97
gris	85,6822	32,6681	10,6644	20,0785	—	2,68	0,19	0,37
sab	85,5641	11,1154	1,0702	7,6221	14,9091	—	3,43	1,30
rosa	40,1762	28,2083	14,8163	4,3912	33,3432	13,2701	—	0,89
phae	56,6743	34,1637	4,7392	9,6963	28,6237	19,8033	22,4351	—

In order to eliminate errors as much as possible, two discriminant functions using skull measurements were elaborated. The first discriminant function makes it possible to differentiate between *Lemniscomys roseveari* and the species of the *L. griselda* species-group from East and South Africa.

$$K = -3,454 \times \text{PAF} + 3,543 \times \text{DIA 2} - 5,417 \times \text{UPTE} + 5,950 \times \text{UPDE} + 20,819 \times \text{M}^1 - 26,96$$

If  $K > 0$  then the specimen is a *Lemniscomys roseveari*; if  $K < 0$  it is a species of the *L. griselda* species-group. The chance of an erroneous determination is 6,8%. In the material examined two *Lemniscomys roseveari* and eight *L. rosalia* (from the Transvaal and Namibia) were misidentified with this function. If the eighteen available factors are used for a discriminant function, this percentage drops to 4,9.

The second discriminant function, using three factors, makes it possible to differentiate *Lemniscomys roseveari* from the adjacent *L. griselda*. It gives a 1,9% chance of an erroneous determination.

$$K = 14,074 \times \text{PRCO} - 14,581 \times \text{HEBA} - 10,880 \times \text{PAF} + 21,85$$

Specimens of *Lemniscomys griselda* give negative values for K whereas specimens of *L. roseveari* give positive ones.

VAN DER STRAETEN: NEW SPECIES OF LEMNISCOMYS FROM ZAMBIA

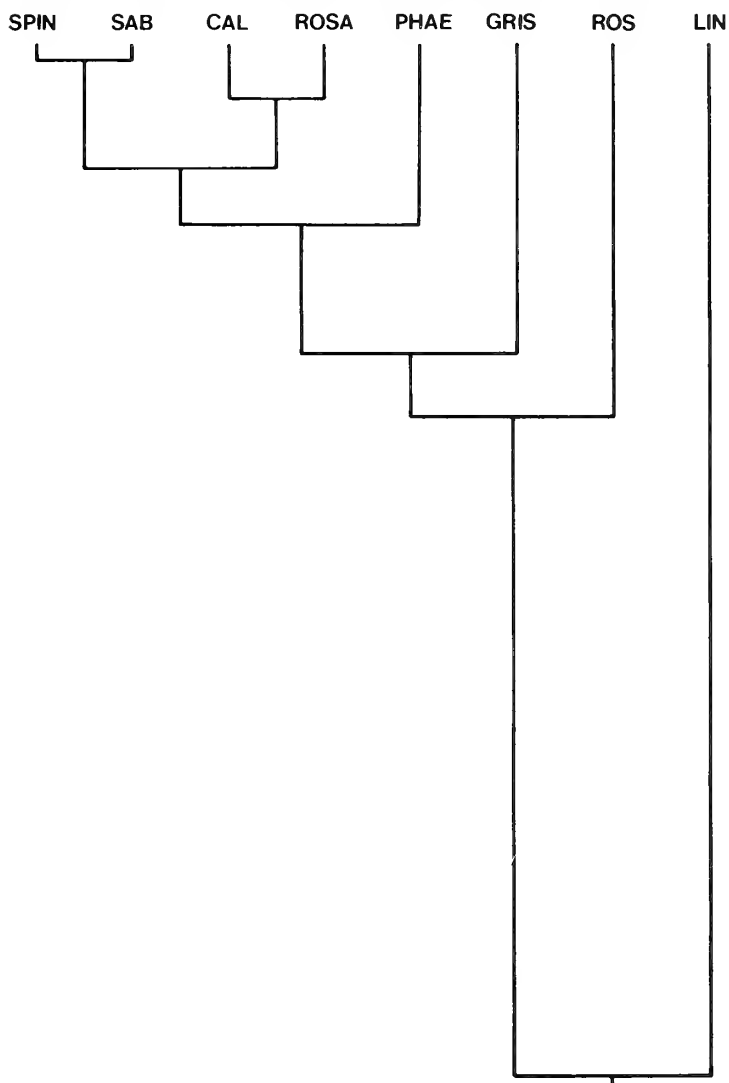


Fig. 2. Dendrogram, based on a matrix of generalized distances of Mahalanobis, generated by the U.P.G.M.A. clustering methods; spin: *Lemniscomys rosalia* (cf. *spinalis*), sab: *L. rosalia* (cf. *sabulata*), cal: *L. rosalia* (cf. *calidior*), rosa: *L. rosalia* (cf. *rosalia*), phae: *L. rosalia* (cf. *maculosus*), gris: *L. griselda*, ros: *L. roseveari*, lin: *L. linulus*.

### ACKNOWLEDGEMENTS

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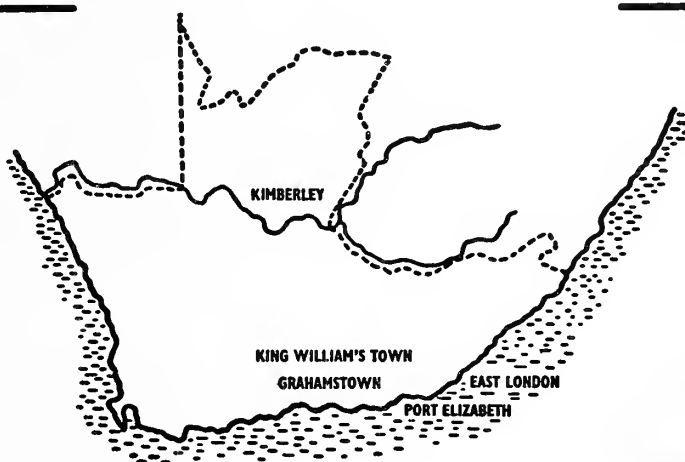


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Ethological studies of *Jugurtia confusa* Richards, *Ceramius capicola* Brauns, *C. linearis* Klug and *C. lichtensteinii* (Klug) (Hymenoptera: Masaridae) in the Eastern Cape Province of South Africa

by

F. W. GESS and S. K. GESS  
(Albany Museum, Grahamstown)

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ABSTRACT

Some aspects of the ethology of *Jugurtia confusa* Richards, *Ceramius capicola* Brauns, *C. linearis* Klug and *C. lichtensteinii* (Klug) (Hymenoptera: Masaridae) in the Eastern Cape Province of South Africa are described. The account of the ethology of *J. confusa* is the first published for *Jugurtia*. Those of the three *Ceramius* species clarify some uncertainties and misconceptions in the literature and add to the overall picture of the ethology of the genus.

INTRODUCTION

The two Old World genera *Ceramius* Latreille and *Jugurtia* Saussure each encompass about twenty-five described species the greatest concentration of which is found in southern Africa, particularly in the Cape Province. The remaining species are scattered over Africa north of the Sahara, southern Europe, Turkey, Armenia, and in the case of *Jugurtia* North-West Africa (Northern Nigeria, Upper Volta, Gambia and Senegal), Yemen and Persia.

Nothing has hitherto been published concerning the ethology of any *Jugurtia* species. With respect to *Ceramius* species a general outline of the ethology may be assembled from the publications of Fonscolombe (1835), Giraud (1871), Ferton (1901), Brauns (1910) and Gess (1965, 1968 and 1973). However, despite the number of publications dealing with the nesting of *Ceramius* species certain aspects have never been described. On the other hand incorrect interpretation of observed facts has led to the presence in the literature of uncertainties or misconceptions, chiefly connected with the form of cell provisioning practised.

The present paper is based upon field work carried out over a period of years at Hilton, a farm situated 18 kilometres WNW. of Grahamstown (33° 19'S., 26° 32'E.) in the Albany Division of the Eastern Cape Province of South Africa and as such is the seventh of a series of publications dealing with the ethology of certain solitary wasps occurring at that locality. The account is augmented as indicated in the text by a few observations made at Clifton, a farm situated 7 kilometres NNE. of Hilton. An account of the climate and vegetation of Hilton and Clifton has previously been given (Gess and Gess, 1974: 191-192).

#### DESCRIPTION OF THE NESTING SITES

The sites chosen for nesting by *Jugurtia confusa* Richards, *Ceramius capicola* Brauns, *C. linearis* Klug and *C. lichtensteinii* (Klug) on Hilton lie within the area utilized by *Dichragenia pulchricoma* (Arnold), *Bembecinus cinguliger* (Smith) and *Parachilus insignis* (Saussure) and described for these species (Gess and Gess, 1974, 1975 and 1976) as localized patches of bare clay earth occurring in low-lying areas, sparsely covered by small low-growing shrubs, largely *Pentzia incana* (Compositae), and situated close to temporary sources of water. *Pentzia incana* only is mentioned as being the dominant plant. For the purpose of this study it must, however, also be mentioned that the second most dominant plant is *Chrysocoma tenuifolia* (Compositae) and that there is in addition a lesser scattering of low-growing Mesembryanthemaceae including *Drosanthemum parvifolium*, *Drosanthemum floribundum* and *Ruschia* species. The nesting of the four species of masarids appears to be very localized as, although an extensive search was made, they were found to make use of only a few of the available apparently similar bare areas and to utilize the same sites each year. The chosen sites lie on both sides of a water furrow mentioned in Gess and Gess (1974, 1975 and 1976) and on a flat area between the furrow and a small shallow earthen dam situated below the former. Water is provided in shallow rainwater pools in the furrow in which water only flows for short periods after rain.

*J. confusa* and *C. capicola* nest in pseudo-colonies on level bare patches caused by sheet erosion or by the presence of a road or path and it seems probable from the situation of the single nest of *C. linearis* discovered that this species selects similar areas. *J. confusa* and *C. capicola* have not been found nesting in close proximity either to each other or to any of the other ground-nesting wasps with the exception of *Bembecinus cinguliger* although this was more in the nature of a fringe overlap in time and space. A single nest of *J. confusa* was found also in a pocket of clayey soil on a horizontal ledge of a raised river bank at some distance from the main nesting area. A second species of *Jugurtia*, *J. braunsiella* (von Schulthess) has occasionally been collected at Hilton but its nests have not as yet been located. *C. lichtensteinii* differs from the other three species of masarids under consideration in that it favours raised bare ground for nesting purposes, the nests located having been either on raised earth around a shrublet in an eroded area or else on artificially constructed banks of a furrow and of small drainage channels. Similarly, on the farm Clifton, *C. lichtensteinii* nests on raised banks of bare clayey soil on the sides of a donga (erosion gulley). At Clifton where *C. lichtensteinii* is more common than at Hilton, it has been found to nest in populous pseudo-colonies, thirty nests having been counted within an area of about a square metre.

#### FLIGHT SEASONS, DAILY FLIGHT PERIOD, LOCATION OF MATING AND OF SHELTERING

The flight periods for the masarids under consideration, like those of all clay-nesting wasps, are variable according to the climatic conditions prevailing in a particular year. Certain generalisations may, however, be made. The species sighted earliest are *J. confusa* and *J. braunsiella* which have been collected at Hilton as early as late September. The most abundant nesting observed for *J. confusa* was in the summer of 1976-77 when the greatest activity was

from early November to mid-December after which there was no activity till mid-February to early April when there was a second but insignificant flush. In other years when the rain has been late there has been a shift in activity to January-February but this was less successful than in the years when nesting was early in the summer.

*C. capicola* and *C. lichtensteinii* are normally reaching their peak after the high-point of activity of *J. confusa* is over. Again the intensity of activity and the extent in time is governed by the climatic conditions in any particular year, however, early December to early January seems to be the most favourable time for these two species.

A nesting date for *C. linearis* is only known from one nest found on 10.xii.1974, however, from collecting dates for this species in the area it seems to be flying most commonly in November-December and therefore its greatest activity is probably somewhere between that of *J. confusa* on the one hand and *C. capicola* and *C. lichtensteinii* on the other.

The males appear in numbers shortly before the females and are present for most of the flight period, becoming scarce as the season advances. The hottest part of the day shows the greatest activity and this is the time favoured for nesting activities. *J. confusa* males were observed to fly low, 5-8 cm above the ground, particularly skirting bushes at the periphery of the nesting site and also alighting on the ground within the nesting area where they sun themselves and rise up to chase the females and each other. They are seen to descend rapidly upon the females and although mating was not observed it seems likely that it takes place within the vicinity of the nesting area. The females were always seen alone at the water where they stand on the mud at the edge of the water to fill their crops. Two females of *J. braunsiella* were collected whilst similarly engaged. In the three species of *Ceramius* on the other hand both males and females were observed together at the water and the females filled their crops whilst standing on the surface of the water. In *C. capicola*, the only species present in large numbers at Hilton, both sexes were frequently observed flying up and down the length of a puddle. They flew over the water 5-8 cm above the surface. The females frequently alighted on the water surface, the legs being held wide-spread. While thus resting on the water surface and gently drifting, the males were seen to alight on top of the females, when both would take off and fly away together, the male above the female grasping her. This was presumably followed by mating. The behaviour of *C. linearis* and *C. lichtensteinii* at the water and preparatory to mating was observed at Hilton and more particularly at Clifton to be identical to that of *C. capicola* as described above.

When the sun was obscured by cloud or when a breeze got up females of *J. confusa*, *C. capicola* and *C. lichtensteinii* were found to be sheltering in their nests. Those of *J. confusa* were seen backing down their burrows into the sheltering position, head uppermost about 5 mm below the opening of the shaft.

#### PLANTS VISITED BY ADULT WASPS AND COMPOSITION OF PROVISION

Records of *Jugurtia* species visiting flowers are few in number: at Hilton *J. confusa* was found on *Drosanthemum parvifolium* (Mesembryanthemaceae) (1 male, 8.xii.1976) and on *Acacia karroo* (Leguminosae) (1 male, 10.ii.1977) and *J. braunsiella* was found on *Lasiospermum bipinnatum* (Compositae) (1 male, 12.x.1977); at Clifton *J. braunsiella* was found on *Pteronia paniculum* (Compositae) (1 female, 27.x.1972). A female *J. confusa* caught in flight was found to be carrying an abundance of pollen on the fore-tibiae and tarsi which are covered with dense hairs, on the swollen antennae, and on the labrum and front of the clypeus.

Flower-visiting records pertaining to *Ceramius* species at Hilton are likewise few in number: *C. linearis* on *Drosanthemum floribundum* (Mesembryanthemaceae) (1 male, 29.xi.1976) and *C. lichtensteinii* on a 'purple mesem' (Mesembryanthemaceae) (1 male, 26.x.1977) and on *Senecio pterophorus* (Compositae) (1 female and 2 males, 29.xi.1979; 1 female, 1.xii.1979; 2 males, 2. xii.1979). However, both males and females of *C. capicola*, *C.*

*linearis* and *C. lichtensteinii* have previously been recorded in the Grahamstown district on various species of Mesembryanthemaceae (Gess, 1973: 115-116).

The provision supplied by *J. confusa*, *C. capicola*, *C. linearis* and *C. lichtensteinii* for the nourishment of their young is pollen bound together with nectar to form a loaf which partially fills the cell. This pollen bread varies in consistency from dry and firm in *C. linearis* and *C. lichtensteinii* to moist and sticky in *J. confusa* and *C. capicola*.

A sample of pollen loaves was examined microscopically for each species, the pollen of the provision being compared with that of flowers found in the vicinity of the nesting area, including species of Mesembryanthemaceae and Compositae. In all cases it was found that the pollen used was that of Mesembryanthemaceae. With respect to the species of Mesembryanthemaceae present in the vicinity of the nesting areas an attempt was made to match the pollen by size with that used in the formation of the pollen loaves. In the case of *J. confusa* five pollen loaves were examined and one pollen size was found to be common to all and was matched with that of *Drosanthemum parvifolium*. However, some loaves contained in addition one or two other pollen sizes but these were not successfully matched. *C. capicola* loaves contained only one size of pollen which was matched with that of *Drosanthemum floribundum*. The *C. linearis* loaf on the other hand contained pollen of three sizes one of which matched with that of *Drosanthemum floribundum*. *C. lichtensteinii* was found to be using pollen of the same size as that of several species of *Ruschia*.

#### DESCRIPTION OF THE NEST

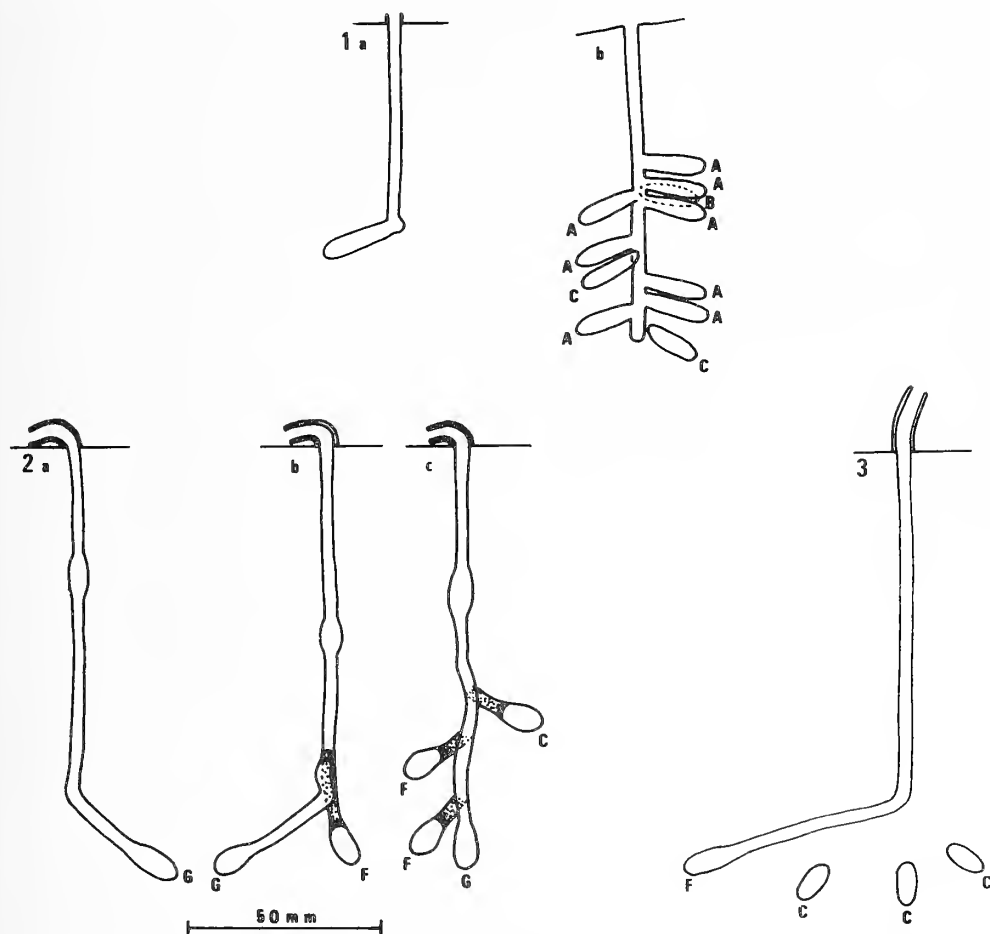
The nests of *J. confusa*, *C. capicola*, *C. linearis* and *C. lichtensteinii* all consist of a subterranean burrow surmounted by a cylindrical mud turret constructed from mud pellets cemented together; in *J. confusa* loosely so that in some cases the turret has a lacy appearance; in *C. capicola*, *C. linearis* and *C. lichtensteinii* closely and smoothed on the inside so that open interstices are extremely rare except near the free end in turrets of *C. lichtensteinii*. In all four species the turret is initially vertical to sub-vertical but, if of any considerable length, curves over becoming horizontal as in *C. lichtensteinii* or curves downwards and then, sometimes, continues in a horizontal plane close to the ground but always free from it as in *C. capicola*. In *J. confusa* more than a short vertical turret is extremely rare and may be considered aberrant.

The subterranean burrow of a newly-constructed nest consists of a vertical shaft which is either of constant diameter along its length as in *J. confusa* or has in the upper third a short bulbous portion as in *C. capicola* and *C. lichtensteinii* and from which at its lower end there branches a subhorizontal secondary shaft terminating in an excavated-cell within which is a constructed mud-cell in *J. confusa* and *C. lichtensteinii* but not in *C. capicola* and *C. linearis*.

In nests at a more advanced stage of construction further secondary shafts each terminating in a cell are present. In *J. confusa* and *C. lichtensteinii* a secondary shaft including its cell is barely longer than the cell itself whereas in *C. capicola* and *C. linearis* it is considerably longer than the cell. *C. linearis* differs from the other three species in that, in the single nest excavated, the cells all lay at a similar depth below the lower end of the main shaft whereas of those in the other three species only the deepest cell lies below the lower end of the main shaft, the other cells being at varying depths above it. In *C. lichtensteinii* the cells are arranged in loose whorls, one or two whorls being constructed in a single year. Additional whorls are constructed in succeeding years. These nests are therefore perennial in nature as probably are those of *J. confusa*.

All completed cells are sealed with a mud-plug which, in constructed mud-cells, takes the form of a stopper fitting into the neck of a cell like a cork into a bottle. The section of a secondary shaft between the sealed cell and the main shaft is filled with tightly packed earth and its opening to the main shaft sealed with a mud-plug.





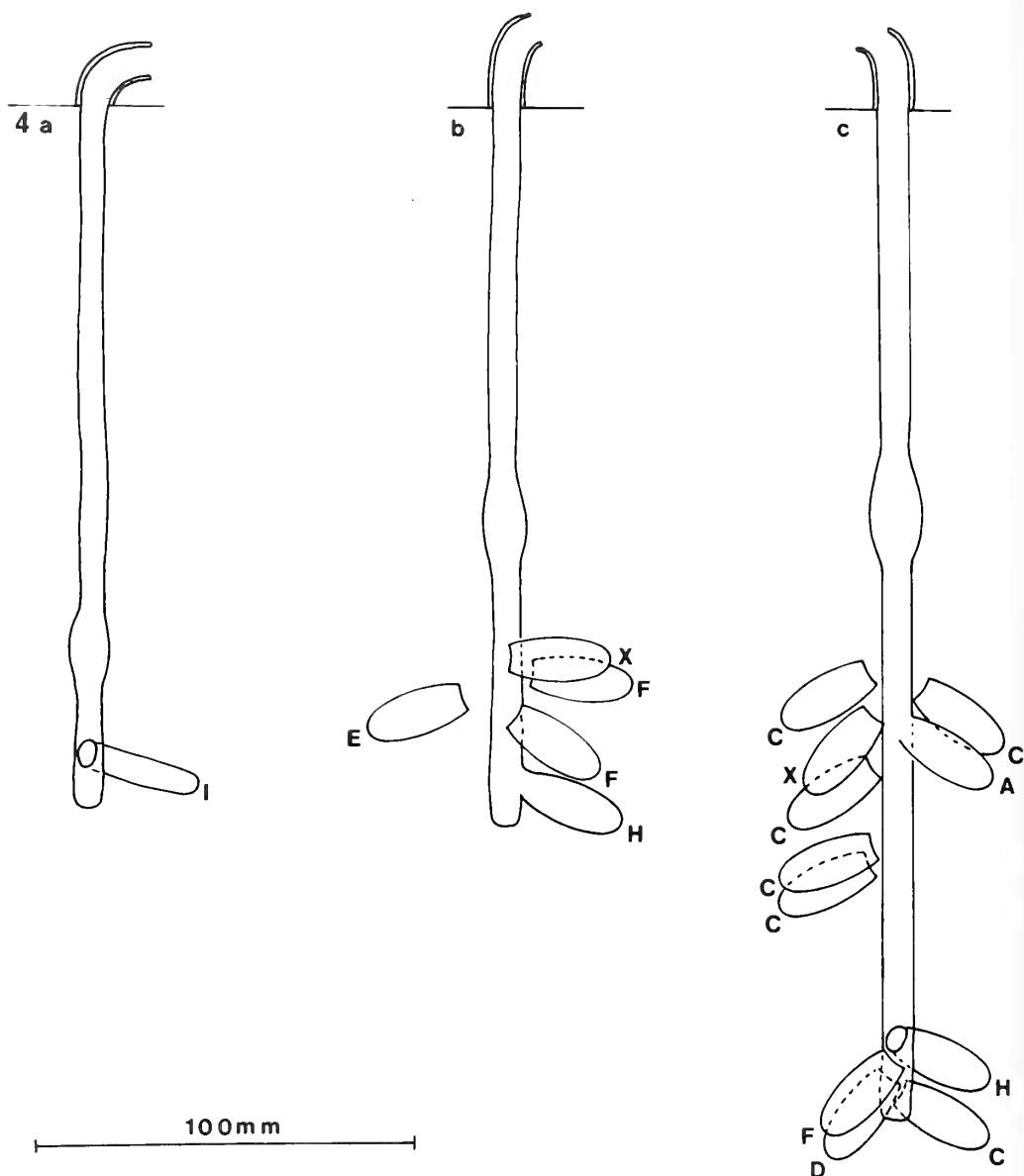
Figs 1-3. Vertical plans of the turrets and underground workings of the nests of three species of Masaridae at Hilton.  
Lettering of cells as in key.

Figs 1a and b. Two nests of *Jugurtia confusa* Richards, investigated on 8.xi.1976 and 27.ix.1978 respectively.  
Figs 2a, b and c. Three nests of *Ceramius capicola* Brauns, investigated on 7.xii.1976, 9.xii.1976 and 11.i.1977 respectively.

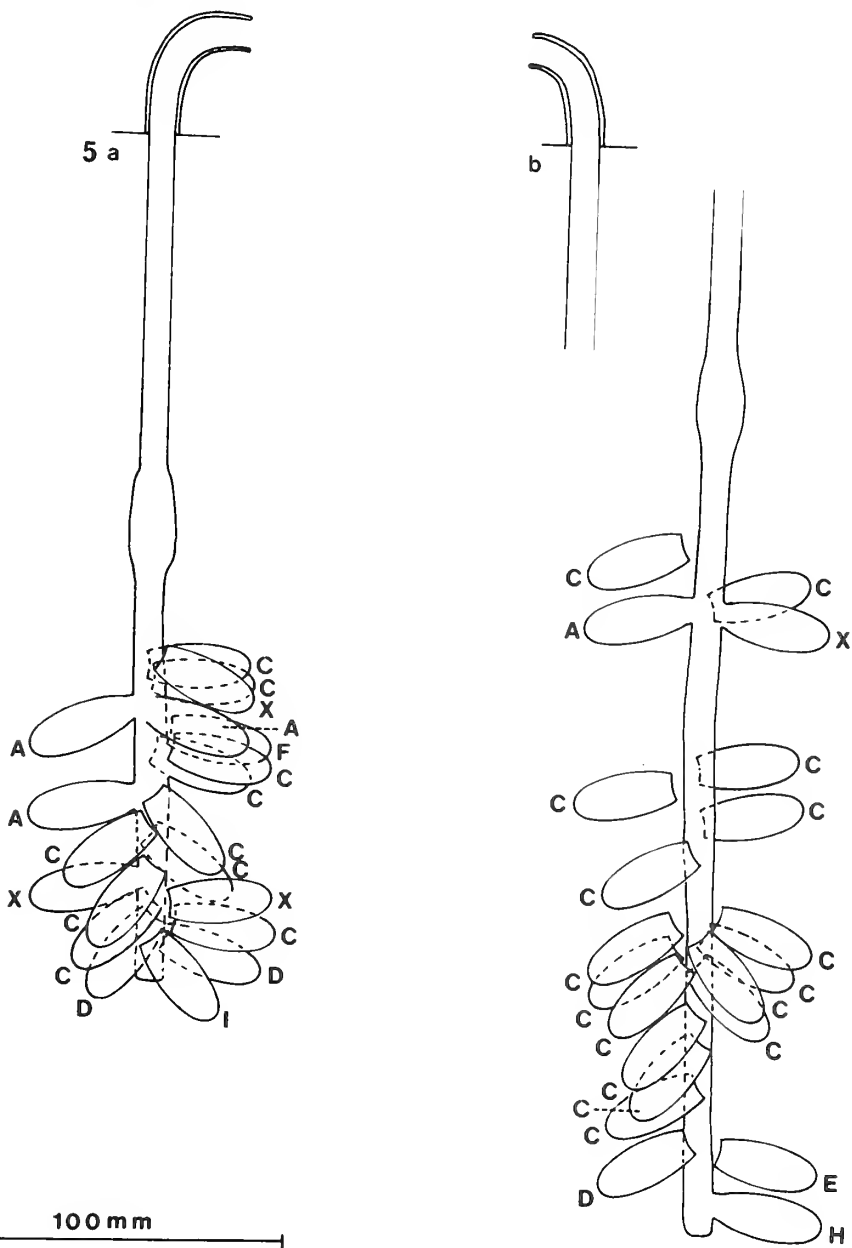
Fig. 3. Single nest of *Ceramius linearis* Klug, investigated on 10.xii.1974.

#### METHOD OF CONSTRUCTION OF THE NEST, OVIPOSITION AND PROVISIONING

The four species studied differ considerably in their size and as body size has a profound effect upon the dimensions of the nest built by each species, total body length and greatest body width (measured across the mesothorax) of average females of each species are given here. *J. confusa* is the smallest species, 10 mm long and 2,7 mm wide; the *Ceramius* species range from *C. capicola*, 12 mm long and 2,9 mm wide, through *C. linearis*, 15 mm long and 3,4 mm wide to *C. lichtensteinii*, 20 mm long and 5,6 mm wide. Males are generally slightly smaller than the females.



Figs 4a, b and c. Vertical plans of the turrets and underground workings of three nests of *Ceramius lichtensteinii* (Klug) at Hilton, investigated on 29.xii.1976, 31.xii.1973 and 3.i.1977 respectively. Lettering of cells as in key.



Figs 5a and b. Vertical plans of the turrets and underground workings of two nests of *Ceramius lichtensteinii* (Klug) at Hilton, both investigated on 3.i.1977. Lettering of cells as in key.

Water is required for nest construction and is collected by a female from a nearby puddle. Whilst filling her crop with water *J. confusa* stands on the mud at the edge of the water whereas the three species of *Ceramius* alight on the water surface.

Nest excavation is initiated by the female's regurgitating water from her crop onto the ground. Using her mandibles she works this water into the earth to form mud from which she forms a pellet. A number of pellets are formed in this way from each crop-full of water. The first pellets excavated from the shaft-initial may be discarded. The shaft-initial is circular in cross section due to the female's rotating evenly, not altering the direction of rotation without first completing a circle. At the commencement of turret construction, the pellets, instead of being discarded, are laid down in a circle around the shaft-initial in such a way that the inner diameter of the turret will be the same as that of the shaft; in *J. confusa* 3 mm (average of sample of 13 measurements), in *C. capicola* 3,2 mm (average of sample of 10 measurements), in *C. linearis* 3,5 mm (one measurement) and in *C. lichtensteinii* 6,2 mm (average of sample of 7 measurements). In the construction of a vertical cylindrical turret pellets are added regularly whereas in a sloping or curved turret more pellets are added to what will be the upper side than to what will be the lower side. It is noticeable that in turrets of *C. capicola* the upper edge of the turret opening projects further than the lower edge.

The method of placement of pellets by *C. capicola* was observed most clearly. The wasp backs up the shaft with a pellet held in her mandibles and reaching the turret opening holds the sides of the turret with her legs whilst placing the pellet in position and smoothing it on the inner surface with her mouthparts and supporting it on the outer surface with the tip of the ventral surface of her abdomen which is curved around for this purpose (Fig. 8). As many as twelve pellets may be added to the turret per water load. If the turret is destroyed by rain or mechanical means, the wasp will build a new one of similar design and dimensions to the original one. In *C. lichtensteinii* and probably also in *J. confusa*, if a newly emerged female instead of initiating a new nest expands a maternal nest, a turret is still constructed at the commencement of nesting. In this case the mud required is obtained from the bottom of the main shaft.

Whilst turret construction is in progress the shaft increases in depth. The diameter of the shaft of *J. confusa* is maintained constant whereas the diameters of the shafts of *C. capicola* and *C. lichtensteinii* after the shafts have reached average depths of 35 mm (sample of 7) and 85 mm (sample of 5) respectively increase to 5,4 mm (average of 7 measurements) and 11,5 mm (average of 5 measurements) after which they decrease to their original measurements. The resultant bulbous portions of the shafts are 10 mm and 24–30 mm long. As the only nest of *C. linearis* excavated was in difficult ground it is not known whether or not this species constructs a 'bulb'.

After completion of the turret the wasp continues to excavate the shaft but the pellets then extracted are discarded. *J. confusa* has no clearly defined pellet-dropping area, however, the wasp does confine her arrivals and departures from the nest to a set quarter segment. Like *J. confusa*, *C. lichtensteinii* has no set pellet-dropping area but discards pellets in bushes at the edge of the clearing in which her nest is situated with the result that the distance from the nest is variable; 60–90 cm in one instance and about 300 cm in another. However, *C. capicola* has a clearly defined pellet-dropping area a few centimetres from and to one side of the turret. When discarding a pellet, a female *C. capicola* backs out from her nest until her head is free from her turret, flies sideways and slightly forwards just above the surface of the ground to the pellet-dropping area, drops the pellet and still orientated parallel to the turret flies in reverse sideways motion back to the nest entrance which she is then facing and enters (Fig. 6). In this way the pellet-dropping operation takes up the minimum of time and exertion and differs from that of most mud-excavating wasps including *J. confusa* and *C. lichtensteinii* which fly up in a wide circle when dropping pellets.

At this stage in nest construction *C. capicola* and *C. lichtensteinii* females when leaving the

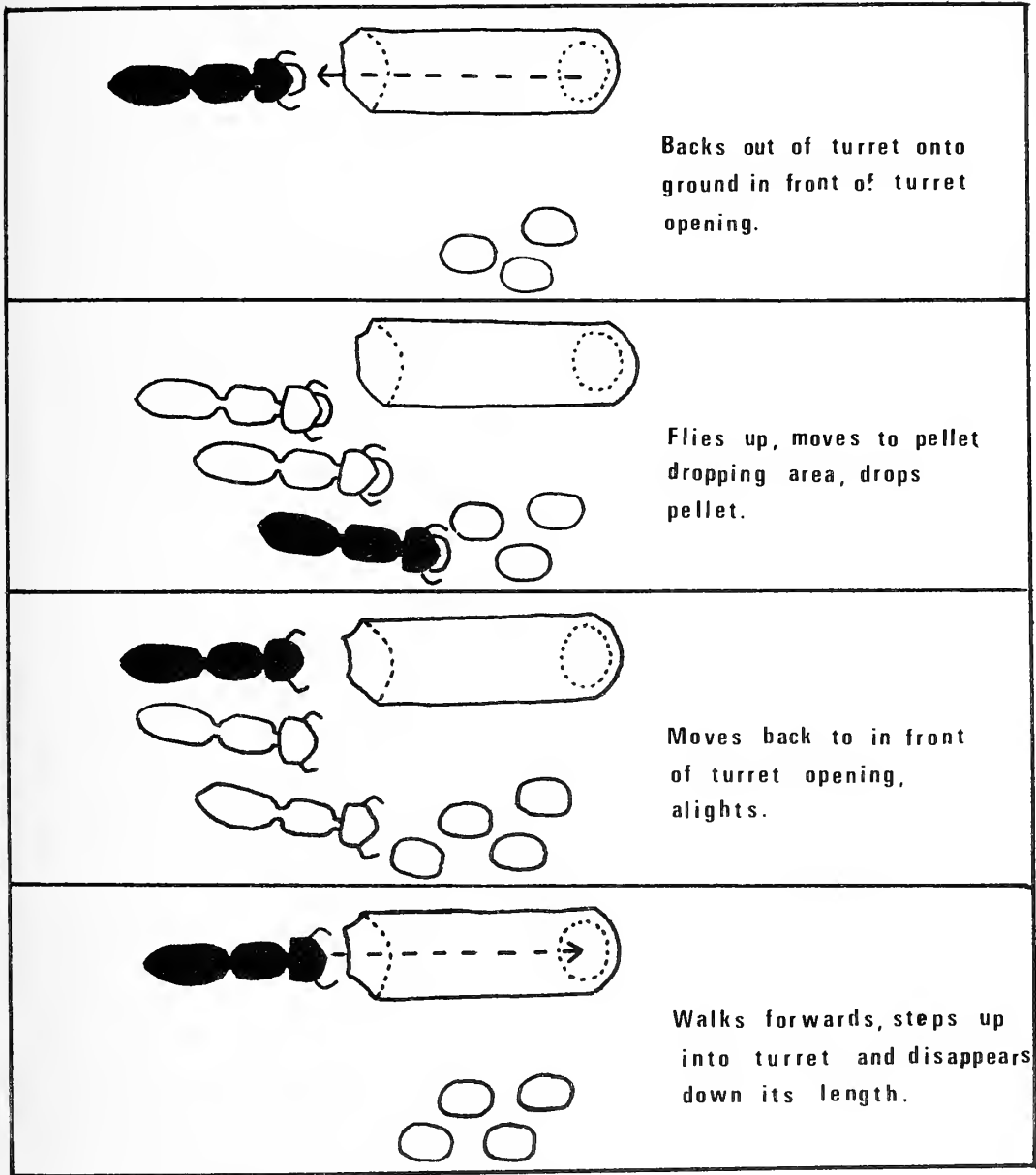


Fig. 6. Sequence showing, in diagrammatic form, the method of pellet deposition after turret construction by *Ceramius capicola* Brauns.

nest to fetch water emerge from the turret head first whereas those of *J. confusa* still continue to emerge backwards. It is probable that the *C. capicola* and *C. lichtensteinii* females turn around in the newly constructed bulbous portion of the nest shaft.

Cycles of water carriage and pellet extraction were timed for *J. confusa*, *C. capicola* and *C. lichtensteinii* and were found to be performed rapidly and without interruption during active nest excavation. Water carriage took 1–2 minutes depending upon the distance from the nest to the water source and pellet extraction took 2–4 minutes depending on the dryness and hardness of the soil. Similarly, the number of pellets extracted per water load varied according to the dryness of the soil. Thus at the outset of nest excavation after rain when the surface layers of the soil only were damp wasps were observed to carry out a far larger number of pellets and more rapidly than they did once they had reached a lower level in the soil where the rain had not penetrated.

The shaft is sunk vertically to depths of 37–52 mm (average 43 mm, sample of 18) in *J. confusa*, 75–100 mm (average 89 mm, sample of 10) in *C. capicola*, 135–170 mm (average 150 mm, sample of 7) in *C. lichtensteinii* and 90 mm in *C. linearis* (single nest). From the bottom of the shaft a secondary shaft of the same diameter as the main shaft is constructed in a subhorizontal plane so that the distal end lies deeper than the bottom of the main shaft and is enlarged to form a cell. The average lengths of secondary shafts and of cells of the four species are: *J. confusa* 17 mm (sample of 7) and 15,6 mm (sample of 5); *C. capicola* 24 mm (sample of 10, range 10–45 mm) and 11 mm (sample of 10, range 10–12 mm); *C. lichtensteinii* 33 mm and 29 mm (sample of 10) and *C. linearis* 30 mm and approximately 12 mm (sample of one). The average diameters of cells are: *J. confusa* 5 mm (sample of 5); *C. capicola* 6 mm (sample of 10); *C. lichtensteinii* 11 mm (sample of 7); and *C. linearis* approximately 6 mm.

After cell excavation has been completed the cells of *C. capicola* and *C. linearis* are ready for oviposition whereas in *J. confusa* and *C. lichtensteinii* a mud-cell is first constructed within each excavated-cell. Mud for the construction of these cells must be quarried within the nest as these wasps do not fetch mud from elsewhere. In nests of *J. confusa* in which a mud-cell has been constructed there is an enlarged 'heel' at the bottom of the shaft. It is thought probable that at least part of the mud used in constructing the mud-cell is excavated from this source and that the mud used by *C. lichtensteinii* is similarly obtained by a deepening of the lower end of the main shaft. The mud-cells are easily separable from the walls of the excavated-cells. They have a rough outer surface on which the separate applications of mud are discernable. The inner surface, however, is carefully smoothed. The average thickness of the walls is 0,7 mm in *J. confusa* and 0,9 mm in *C. lichtensteinii*.

Oviposition takes place before the commencement of provisioning. The eggs are strongly curved, white in *J. confusa* and *C. capicola*, whitish-yellow to pale yellow in *C. lichtensteinii*, and are of average dimensions 2,51 mm by 0,76 mm (sample of one), 3,55 mm by 0,89 mm (sample of 8) and 6,24 mm by 1,42 mm (sample of 7) respectively.

The cell is then rapidly provisioned and sealed before the egg hatches. Exceptionally, open cells of *C. lichtensteinii* were found containing a young larva and little or no pollen bread. Thus, at Hilton during the period 12–31.xii.1973, of nine open cells in which oviposition had taken place seven contained eggs only and no provision, one contained a newly hatched larva (5 mm in length) and no provision, and one contained a small larva (6 mm in length) and a small amount of provision. However, of ten newly sealed cells, one contained an as yet unhatched egg and a complete pollen loaf and nine contained larvae of various sizes ranging from newly hatched (5,5 and 6 mm in length) to large with varying amounts of as yet unconsumed provision in inverse proportion to larval size. It therefore appears that under favourable conditions the cell is fully provisioned and sealed before the egg hatches but that, exceptionally, under unfavourable conditions such as bad weather, when 'mesem' flowers stay closed and wasps do not readily fly, or such as a scarcity of forage flowers the beginning of provisioning may be preceded by the hatching of the egg.

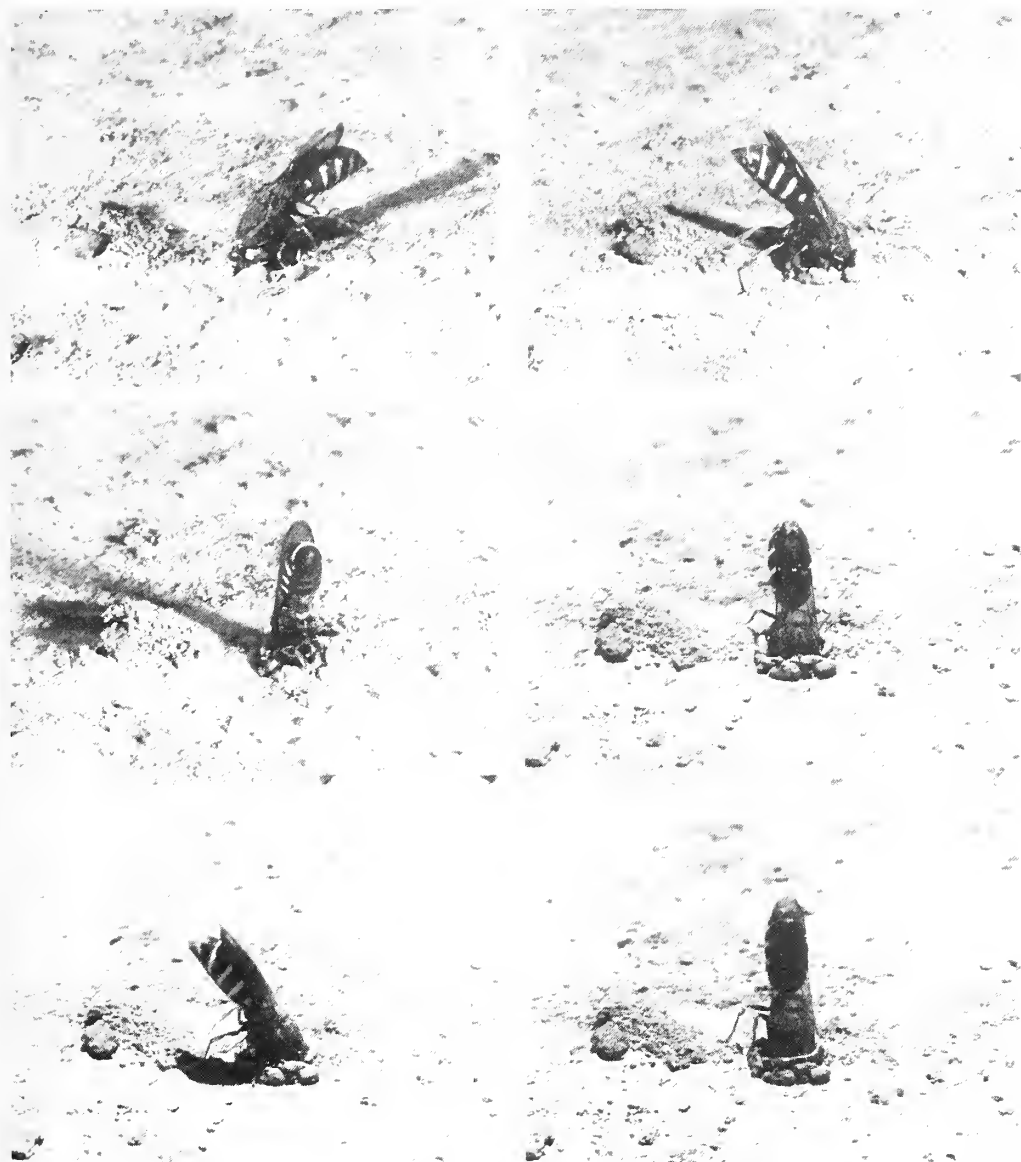


Fig. 7. Hilton, 10.xi.1976. Sequence showing shaft sinking and turret building by *Jugurtia confusa* Richards. (x2,4)

After a cell has been sealed the remaining section of the secondary shaft is filled with earth and sealed off from the vertical shaft with mud which is smoothed so that the entrance to a secondary shaft, once it is sealed, is no longer visible on the surface of the main shaft. *C. capicola* and *C. linearis* do not introduce earth into the nest from elsewhere and so the earth for filling a secondary shaft must be obtained within the nest and can only come from the excavation of another secondary shaft. Succeeding cells are constructed in the same manner, the number probably being dependent on the availability of water for nest construction and pollen and nectar for cell provisioning.

Twenty newly-constructed nests of *J. confusa* were excavated in the summer of 1976–77 and of these eleven contained one cell each (Fig. 1a) and nine were still at the stage of shaft excavation. Due to the drying out of the water supply nesting in the pseudo-colony to which these nests pertained ceased at this stage. However, the single nest found on the river bank and excavated in September, 1978, a year after it had first been noted contained eleven cells (Fig. 1b). This nest had a shaft 81 mm in depth with the cells radiating out from the shaft at depths of from 35–79 mm. Eight cells were open, empty and parchment-lined and were therefore cells from which the occupants had already emerged. Three cells were sealed, one containing an adult female ready to emerge and the other two each a prepupa. In addition one adult female was coming into and out of the nest and one male was sunning itself on the ground next to the nest. It seems highly probable that this nest may have been a perennial one.

Sixteen nests of *C. capicola* were excavated in the summer of 1976–77 and of these seven were one-celled (Fig. 2a), three two-celled (Fig. 2b), one four-celled (Fig. 2c) and the remaining five nests had not reached the stage of cell excavation.

The single nest of *C. linearis* excavated in the summer of 1974 contained four cells (Fig. 3).

Nineteen nests of *C. lichtensteinii* were excavated in the summer of 1973–74 and of these six were newly constructed (Fig. 4b) and thirteen had been initiated one or two years previously. A further five nests were excavated in the summer of 1976–77. Of these one nest was newly constructed (Fig. 4a) and the remaining four nests had been initiated one or two years previously. These four nests contained eleven (Fig. 4c), fifteen, twenty (Fig. 5a) and twenty-one (Fig. 5b) cells arranged in whorls of three to seven or more cells. As there seems to have been a low percentage of emergence of *C. lichtensteinii* at Hilton during the years when observations were made the infrequency of occurrence of newly constructed nests is not surprising.

### LIFE HISTORY

Little information was gathered concerning the immature stages of the four masarid species. Hatching of the larva of *C. lichtensteinii* appears to take place about three days after oviposition for of four eggs obtained from unprovisioned open cells excavated on 31.xii.1973, one hatched on 2.i.1974 and three hatched on 3.i.1974.

After consuming the stored provision the then mature larva spins its cocoon which in *C. lichtensteinii* is parchment-like, brittle, brown in colour and in intimate contact with the inner end and the walls of the mud-cell from which its detachment is difficult. The posterior end of the cocoon—that is the end towards the inner end of the cell is rounded, whereas the anterior end of the cocoon—that is the end towards the mud-plug closing the mud-cell is truncate and is in the form of a flat circular plate separated from the mud-plug by an empty space. Cocoons of *C. lichtensteinii* measured from 19,0–21,5 mm in length, from 7,3–9,0 mm in width at their middle (where widest) and from 6,3–7,0 mm in width at their truncate end. The empty space between the truncate end of the cocoon and the inner surface of the mud-plug was from 4–8 mm long.

Having spun the parchment cocoon the larva changes into a prepupa characterised by its hunch-backed and flaccid appearance. Diapause takes place in the prepupal stage and may last until the following spring or may be extended over longer periods. Development after pupation in the spring appears to be rapid.



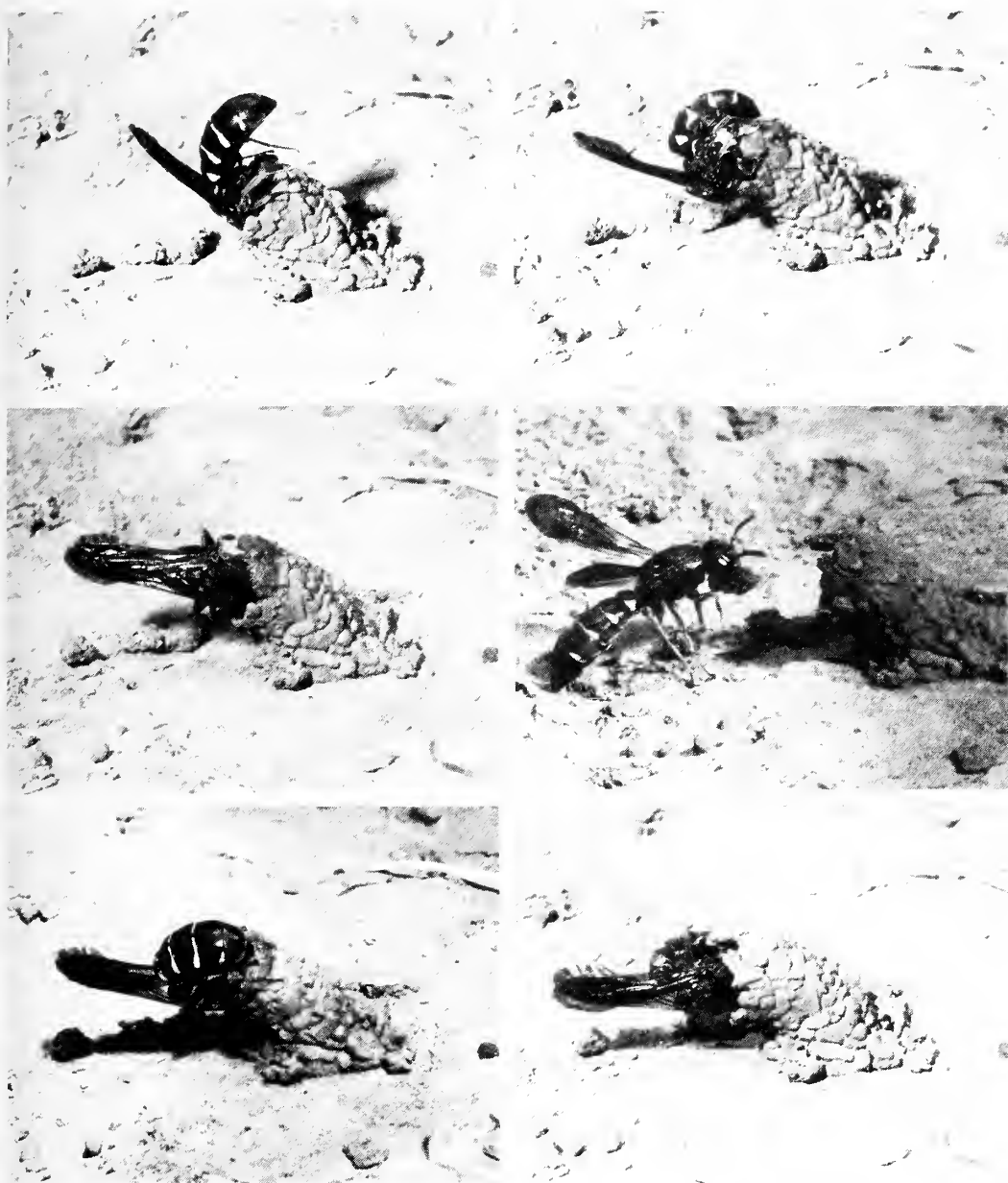


Fig. 8. Hilton, 6.xii.1976. Sequence showing turret building by *Ceramius capicola* Brauns. (x2,5)

## PARASITES AND OTHER ASSOCIATED INSECTS

Parasites of Masaridae recorded at Hilton consist of species of Chrysididae, Mutillidae and Meloidae.

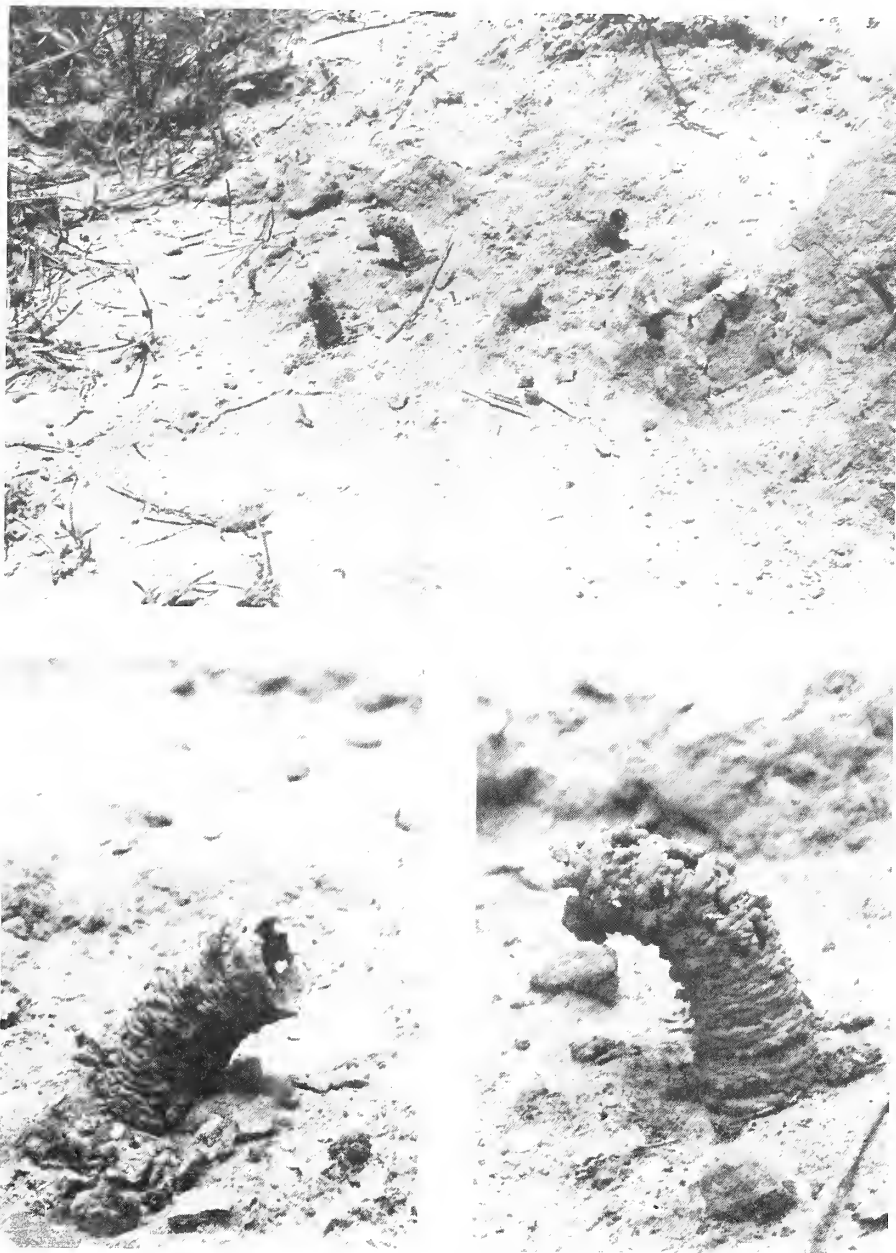
The genus *Allocoelia* (Chrysididae), the species of which as far as is known are all parasitic in the cells of Masaridae, was found to be represented at Hilton by *A. bidens* Edney. During the period 8–19.xi.1976 seven females of this small species were caught resting on the ground in the nesting area of *J. confusa* which without doubt constitutes its host. The appearance of the chrysidid coincided with the beginning of the nesting period of its host.

Though not yet collected at Hilton there seems to be no reason why other species of *Allocoelia*, namely *A. latinota* Edney and *A. capensis* Smith should not also occur there as both species have been collected in nearby vicinities. Thus *A. latinota* has been found associated with nesting *C. capicola* at Strowan and at Grahamstown (Cradock Dam), with *Ceramius* species (*capicola*, *lichtensteinii* and *linearis*) at Alicedale and with *C. linearis* at Kenton-on-Sea (Gess, 1973: 118–119). *A. capensis* was found associated with an extensive pseudo-colony of *C. lichtensteinii* on the farm Clifton on 7.i.1979 (D. W. Gess) and was recorded by Brauns (1910: 446) as parasitic in the cells of this wasp at Willowmore. The relative smallness of the nesting aggregations of *Ceramius* species at Hilton compared with the large pseudo-colonies of *C. capicola* and *C. lichtensteinii* located at Strowan and at Clifton respectively is the probable reason why the *Allocoelia* species parasitic in the nests of these wasps have not yet been collected at the former locality.

Three *C. lichtensteinii* cells that showed clear evidence of parasitism by Mutillidae were found in a nest excavated on 25.i.1973. In each instance there was an emergence hole sited in or near the mud-plug sealing the mud-cell and another in the truncate, disc-like anterior end of the parchment-like *C. lichtensteinii* cocoon within. The mutillid emergence hole in the truncate cocoon end was situated in the centre of the disc and left the edges of the latter attached to the sides of the cocoon. By contrast, *C. lichtensteinii* itself when emerging from its cocoon removes the disc entirely. Within each of the three *C. lichtensteinii* cocoons was found the smaller, very tough and leathery cocoon of the parasite, the space between the two cocoons being almost completely filled with very extensive, tough, brown silken spinings. Also found in the space between the two cocoons was in one case the dry shrivelled remains of the mature larva or prepupa of the host and in the other two cases the remains of the host pupae. The mutillid cocoon, orientated the same way as the host's cocoon, had at its hind end an extensive deposit of meconium. In the same nest was found a live female *Dasyabroides caffra* (Kohl). The fine state of the vestiture and the completely unworn mandibles indicated that this individual had just emerged, doubtless from one of the three parasitized cells.

Subsequently six adults of *D. caffra* were reared from *C. lichtensteinii* cells excavated at Hilton and kept in Petri dishes in the laboratory. Three cells excavated on 5.xii.1973 yielded a male (on 17.i.1974) and two females (on 28.ii.1974 and 31.i.1975) and three cells excavated on 27.xii.1973 yielded three females (on 17.iii.1974, during January, 1975, and on 31.i.1975 respectively). Examination of the mud-cells and cocoons vacated by the parasites confirmed the earlier findings. It is probable, however, that *D. caffra* is not species-specific as regards its host and that *C. lichtensteinii* is therefore only one of a range of species parasitized.

Two adult specimens of a species of Meloidae, *Ceroctis groendali* (Billb.) were found in the nests of *C. lichtensteinii*. In addition, six meloid larvae in various stages of development were found associated with the cells of this wasp. Though none of these larvae was reared through to the adult stage and proof of the larvae's identity is thus not available, it is nevertheless believed that they were conspecific with the adults. On this assumption it may be stated that *C. groendali* is a fairly common cleptoparasite or predator in the nests of *C. lichtensteinii* where in its larval stage it feeds either upon the stored pollen loaf after first destroying the egg or newly hatched larva of the wasp or upon the fully grown larva itself. The eight individuals of the meloid found



Figs 9a, b and c. Hilton, 3.i.1977. Nest turrets of *Ceramius lichtensteinii* (Klug).  
Fig. 9a (x0,4); Figs 9b and c (x1, 85)

in association with *C. lichtensteinii* nests are dealt with in an order determined by their developmental stage when found.

A triungulin larva with darkly pigmented body and with well developed long legs and long slender cerci was found in a sealed cell on 12.xii.1973, situated on the pollen loaf next to the *C. lichtensteinii* egg the hatching of which appeared to be imminent. Kept in a gelatin capsule this triungulin larva moulted to give rise to the second (caraboid) instar before dying.

A small larva, probably early third (first scarabaeoid) instar was found on 31.xii.1973 in a sealed cell containing a pollen loaf and a small, dead *C. lichtensteinii* larva. On the same date another sealed cell was found to contain a somewhat larger larva and a pollen loaf considerably reduced in size. This larva, kept in a gelatin capsule, continued to feed for some time on the pollen loaf but died as a large fourth (second scarabaeoid) instar larva.

A small larva, probably early third (first scarabaeoid) instar was found on 3.i.1977 in a sealed cell containing a large pre-spinning *C. lichtensteinii* larva and no pollen. The two larvae were transferred to a gelatin capsule and when next examined on 6.i.1977 the beetle larva was found to have grown considerably and to have eaten a hole into the wasp larva which it had thereby killed. The beetle larva moulted on 7.i.1977 and again between this date and 12.i.1977 when it was fully grown, having eaten all of the *C. lichtensteinii* larva except its skin. Transferred onto damp sand in a Petri-dish it moulted to the coarctate resting larval stage on the surface of the sand after a period of restless tunnelling through the sand. At the time of writing (March, 1980) the larva was still in a state of diapause.

A fully developed fourth (second scarabaeoid) instar larva (circa 10 mm long) was found associated with a *C. lichtensteinii* cell on 27.xii.1973 as was a coarctate resting larva (8 mm long).

The two adult beetles found in the *C. lichtensteinii* nests were both dead. The first was found on 25.i.1973, the second on 5.xii.1973.

*C. groendali* appears to be widespread in its distribution, Péringuey (1909: 218) recording it from "Cape Colony (Port Elizabeth, Grahamstown, East London), the whole of Orange River Colony, Natal, and the Transvaal". As this distribution is far more extensive than that of *C. lichtensteinii* (see Richards, 1962: 102; Gess, 1965: 224, 1968: 10 and 1973: 113) it is clear that *C. groendali* cannot be restricted to this wasp but must have other hosts as well, possibly ground-nesting solitary bees.

It is of interest that Brauns (1910: 446) recorded finding the coarctate larvae or the pupae ("Puppen") of a meloid in the cells of *C. lichtensteinii* at Willowmore. Specific identification was impossible as he was unable to rear them through to the adult stage. It seems possible, however, that the same species, *C. groendali*, was involved.

It is probable that nests of *C. lichtensteinii* may on occasion be utilized for nesting by *Megachile* (*Eutricharaea*) *stellarum* Cockerell. A female of this species was on 3.i.1977 seen entering and afterwards leaving a turreted nest of the wasp and on at least one occasion the remains of an old megachilid leaf nest were found in a turreted nest. Nesting of *M. stellarum* has previously been recorded in abandoned and incomplete burrows of *Dichragena pulchricoma* (Arnold) (Gess and Gess, 1974: 204–206) and the females of this bee have also been observed leaving old burrows of *Parachilus insignis* (Saussure) (Gess and Gess, 1976: 98). As *M. stellarum* nests in pre-existing cavities in the ground it is likely that it will make use of any burrows of suitable size regardless of the identity of their excavators.

## DISCUSSION

The earliest published accounts of the nesting of *Ceramius* species concerned two Palaearctic species observed in southern France: *C. fonscolombei* Latreille at Aix (Fonscolombe, 1835: 426–427) and *C. tuberculifer* Saussure (cited as *C. lusitanicus* Klug—see Richards, 1962: 29

and 112–115) in the area of Hautes-Alpes and in the valley of the Vallouise near Briançon (Giraud, 1871: 375–379) and at Montlouis and Cerdagne (Ferton, 1901: 137–139).

More recent published accounts bearing upon the nesting of *Ceramius* have all been concerned with southern African species observed in the Cape Province: *C. beyeri* Brauns, *C. bicolor* (Thunberg) (cited as *C. karrooensis* Brauns), *C. capicola* Brauns, *C. cerceriformis* Saussure (cited as *C. schulthessi* Brauns), *C. linearis* Klug (cited as *C. fumipennis* Brauns) and *C. lichtensteinii* (Klug) near Willowmore (Brauns, 1910: 387, 445–446), *C. bicolor* (Thunberg) on the banks of the Olifants River between Klawer and Clanwilliam (Gess, 1968: 13), and *C. capicola* Brauns and *C. lichtensteinii* (Klug) on Strowan near Grahamstown (Gess, 1973: 117–119).

Some details at least have therefore been published concerning the nesting of a total of eight *Ceramius* species, three of which, *C. capicola* Brauns, *C. lichtensteinii* (Klug) and *C. linearis* Klug, are the subjects also of the present studies. In order to obtain an overall picture of the ethology of *Ceramius* it is the intention in the present discussion to draw together and compare the various published accounts augmented by the present studies which latter furthermore enable some uncertainties and misconceptions present in the literature to be examined and corrected. At the same time the nesting of *J. confusa* Richards, the first *Jugurtia* species to be examined with respect to its ethology, is compared with that of species of *Ceramius*.

All the species of *Ceramius* enumerated above as also *J. confusa* have been recorded as nesting in the ground, the nests being surmounted by variously shaped mud turrets. The nature of the ground, when recorded, has been given as clayey and hard, bare or at most covered by sparse vegetation (Giraud, 1871; Ferton, 1901; Gess, 1968 and 1973; present paper). Nesting on slightly raised banks has been recorded for *C. fonscolombei* (Fonscolombe, 1835) and for *C. lichtensteinii* (present paper) whereas nesting on level ground has been recorded for *C. capicola*, *C. linearis* and *J. confusa* (present paper).

The formation of pseudo-colonies appears to be common and has been recorded for *C. tuberculifer* (Giraud, 1871; Ferton, 1901), *C. bicolor* (Brauns, 1910), *C. lichtensteinii* (Brauns, 1910; present paper), *C. capicola* (Gess, 1973; present paper) as well as for *J. confusa* (present paper).

The nearness of nesting sites to water is either stated or is implied by all authors and all the species are recorded as visiting this water. In the present paper it has been shown that with respect to the four species studied the purpose of visiting pools is to fill the crop with water which when regurgitated upon the clayey nesting substrate makes the latter more easily worked and thus makes nest construction possible. For *C. capicola*, *C. linearis*, *C. lichtensteinii* and *J. confusa* no evidence was ever obtained by the present authors either during the course of the present study itself or on any of the many occasions on which the species were collected at pools that the wasps were collecting anything but water. Similarly, Ferton (1901) with respect to the pool-visiting of *C. tuberculifer* made it abundantly clear that what the wasp collects is water, not mud, and stated that when captured on her way from a pool a female disgorged into his net her stored liquid ("son liquide").

However, other authors have claimed that some species at least collect not water but mud. Fonscolombe (1835) stated that *C. fonscolombei* went to ponds to collect sodden earth ("terre délayée") but later in his account appears to have been uncertain for he stated that the turret was constructed of pellets derived from the excavation of the nest (which would indicate the collection of water, not mud) or of pellets carried to the nest from without (which would support his earlier contention).

Similarly, Brauns (1910) stated that whereas *C. beyeri*, *C. lichtensteinii* and *C. linearis* settle on the water surface at the middle of the pool and collect water, *C. cerceriformis*, *C. bicolor* and *C. capicola* alight at the edge of the pool and collect mud in little pellets which he maintained are used by them for the construction of their cells and turrets.

With respect to *C. capicola* at least, the present study has shown Brauns to have been mistaken. *C. capicola* differs from *C. lichtensteinii* and *C. linearis* neither with respect to the part of the pool alighted upon nor with respect to what is collected at the pool: water. It seems highly likely that Brauns was mistaken also with respect to the other two alleged mud-collectors, *C. cericeriformis* and *C. bicolor*.

It is of significance to note that alighting at the edge of the pool does not prove that mud, not water, is being collected there. As noted in the present study, *J. confusa* stands on the mud at the edge of the water but fills her crop with water like the three species of *Ceramius* which alight on the actual water surface.

The construction of a mud-cell within the excavated-cell has been reported for *C. tuberculifer* (Giraud, 1871; Ferton, 1901) and for *C. lichtensteinii* (Brauns, 1910). In the present study the construction of such a mud-cell by *C. lichtensteinii* has been confirmed and has been established also for *J. confusa*. However, no mud-cells could be demonstrated for either *C. capicola* or *C. linearis* and these species therefore differ from *C. tuberculifer* and *C. lichtensteinii* in what appears to be an important behavioural character. In the tentative grouping of the species of *Ceramius* given by Richards (1962: 83) *C. capicola* and *C. linearis* are placed in the same species-group together with *C. bicolor* and *C. socius* Turner which may therefore be expected also to omit the construction of a mud-cell.

The mud-cell constructed by *C. lichtensteinii* within the excavated-cell bears a close resemblance to the aerial cell constructed by *Pseudomasaris edwardsii* (Cresson) as described and illustrated by Torchio (1970). It is possible therefore to regard the construction of a mud-cell within an excavated-cell as in *C. tuberculifer*, *C. lichtensteinii* and *J. confusa* as being behaviourally intermediate between the excavation only of a cell as in *C. capicola* and *C. linearis* and the presumably more advanced construction of an aerial mud cell as in the genera *Gayella*, *Masaris*, *Pseudomasaris* and *Celonites*.

With respect to the four species of the present study it is interesting that a correlation exists between the type of cell and the length of the secondary shaft. Thus in *C. capicola* and *C. linearis* the simple excavated-cells terminate long secondary shafts whereas in *C. lichtensteinii* and *J. confusa* the excavated-cells containing the constructed-cells terminate very short secondary shafts.

Oviposition into the empty cell follows the pattern common to all Vespoidea and has been recorded for *C. tuberculifer* (Giraud, 1871; Ferton, 1901), *C. lichtensteinii* (Brauns, 1910; present paper), *C. capicola* and *J. confusa* (present paper). However, with respect to the latter three species no evidence was found during the present study that the egg was in any way attached to the cell wall being always found lying loose on the floor of the cell at its inner end. This is in contrast to the suspension of the egg by a filament from the top or side of the cell as in many Eumenidae or the glueing of the egg to a cell wall as in the Vespidae. The egg of *Pseudomasaris edwardsii* (Cresson) (Masaridae) is reported to be normally anchored by its narrowed posterior tip to the cell wall near its base (Torchio, 1970: 7) but it is not stated how this attachment is effected.

According to Ferton (1901) the egg of *C. tuberculifer* is deposited only provisionally at the bottom of the cell and after the cell has been provisioned with a firm pollen loaf of characteristic retort-like shape (see Ferton, 1901: Plate 1, Fig. 10) the mother moves the egg onto the neck of the "retort", in which position the little larva is alleged to begin feeding. Much as been made of Ferton's assertions by Malyshev (1968: 263) who, in his chapter on the genesis of bees, has based his "Secondary Bee Phase of Vespid Type" upon them.

The present authors cannot accept Ferton's assertions concerning the transfer of the egg by the female wasp from a provisional site of deposition to a pollen loaf specially shaped for its reception. In the cells of *C. lichtensteinii* of which a large number were examined over the years, the egg was left where first deposited and the larva upon hatching found its own way onto the

nearby pollen loaf. There is no reason to suppose *C. tuberculifer* to be different in this respect. Moreover, it is difficult to visualise how it would be physically possible for the female wasp to reposition her egg onto the pollen loaf as the latter would be situated between her and the egg. It is believed that the retort-shape of the pollen loaf described by Ferton was not the result of any moulding by the female wasp but was simply an artifact of the larva's feeding, that Ferton drew the wrong conclusions, and that Malyshev's hypothesis is therefore based upon false premises.

Some confusion exists in the literature as to whether *Ceramius* species practise mass provisioning or progressive provisioning.

Giraud (1871) recorded open *C. tuberculifer* cells each with a larva that either had no provision at all, had varying amounts of provision, or were almost full. The impression gained from the above is that mass provisioning is probably practised. However, somewhat later in his paper Giraud made a statement which may easily be taken ambiguously, namely that it appeared to him evident that the female wasp continues to carry in nourishment after the hatching of the larva, as was demonstrated by the insufficiency of the provision deposited in the cell of the young larva and by the presence of the female in the galleries leading to the cells.

Ferton (1901) with respect to the same species, and as already discussed above, described and figured a pollen loaf which by its completeness clearly indicates mass provisioning rather than progressive provisioning.

Brauns (1910: 445) with respect to *C. lichtensteinii* claimed that he had never found stored pollen and nectar masses in the cells with the larvae, even when the latter were still small and stated that it was certain that the wasp feeds its larvae until such time that they are full-grown, the provision being nectar ("Sicher ist, dass die Wespe ihre Larven solange füttert, bis dieselben erwachsen sind, und zwar mit Blumenhonig.").

Brauns' contention that *C. lichtensteinii* practises progressive provisioning has been mentioned by Richards (1962: 29) who did not comment other than to state that this was not recorded for the European species studied. Torchio (1970: 31), presumably on the strength of Brauns' assertion, has listed the genus *Ceramius* as practising progressive provisioning in contrast to the genera *Euparagia*, *Gayella*, *Paragia*, *Pseudomasaris* and *Celonites* which he lists as not provisioning progressively.

Malyshev (1968: 259) not only accepted Brauns' statement but elaborated upon it, writing that: "This method of progressive feeding of the larvae on honey (*sic!*), provided when it is needed and only given directly into the larva's mouth, is bound to reflect the moment . . . when the instincts of the wasp were transformed into those of the bee". Malyshev's hypothesis once again is based on false premises for in *C. lichtensteinii* provisioning is not progressive.

As was established in the present study and as has been dealt with in some detail earlier in the present publication *C. lichtensteinii* (as also *C. capicola*, *C. linearis* and *J. confusa*) practises mass provisioning, and, under optimal conditions of favourable weather and an abundance of forage flowers, provisioning and sealing of the cell is completed by the female before the egg hatches. Under less favourable conditions the rate of provisioning is slowed down leading to the finding of unsealed cells containing larvae and varying amounts of provision as recorded by Giraud, and under really unfavourable conditions the situation as reported by Brauns results. There is certainly no shred of evidence that *Ceramius* differs in any way in its method of provisioning from the other genera for which this facet of behaviour is known.

Brauns (1910: 445) stated with respect to *C. lichtensteinii* that several females appeared to work in a single nest as he frequently saw several females disappearing one after the other down the same turret. The present authors found no evidence that more than a single female nests in a nest at any one time either with respect to *C. lichtensteinii* or with respect to *C. capicola*, *C. linearis* and *J. confusa*. However, as already stated earlier in the present publication, *C. lichtensteinii* (as also *J. confusa*) has perennial nests resulting from the reuse of the nest in successive nesting seasons by females produced in the nest. The present authors believe Brauns'

misconception may readily be explained by what appears to be the likely sequence of events in a perennial nest at the beginning of the flight season. Thus, at that time it seems probable that the several wasps, both males and females that have emerged from their cells in the nest should initially remain associated with the nest for shelter, returning to it at night or when the weather is unfavourable. It seems likely also that this co-existence in the nest should persist until such time when one of the females, possibly the first-emerged and therefore the most advanced, has reached the stage of maturity when her nesting urges begin, when she takes over the nest and drives out from it the males and the other females which latter have to emigrate and initiate new nests. That both sexes of species of *Ceramius* do for the greater part retire to the nests for the night is recorded by Brauns (1910: 446). Similarly, in the present study, females of *C. lichtensteinii*, *C. capicola* and *J. confusa* were found to shelter in their nests during periods of unfavourable weather. It is therefore believed that Brauns' observation of several females entering a single nest was made during the post-emergence—pre-nesting period at the beginning of the flight season and that the females concerned were sheltering rather than nesting. Brauns' further observation that sometimes both sexes may be found at night perched upon plants (1910: 446) most probably pertains to individuals which have been evicted from the nest in which they developed, the females amongst them not yet having initiated new nests.

Summing up, the picture of the ethology of *Ceramius* and *Jugurtia* which emerges from the studies to date is as follows:

1. Nesting is in the ground.
2. There is a tendency towards the formation of pseudo-colonies.
3. Water is required for the excavation of the nest and is collected from a pool by the female, in *Ceramius* standing on the surface of the water and in *Jugurtia* at the edge of the water.
4. The nest consists of a main shaft and secondary shafts each terminating in an excavated-cell and is surmounted by a turret constructed of mud pellets.
5. *C. lichtensteinii*, *C. tuberculifer* and *J. confusa* in addition construct a mud-cell within each excavated-cell but such constructed mud-cells are absent in nests of *C. capicola* and *C. linearis*.
6. The mud for constructing turrets and mud-cells is obtained entirely from within nest excavations.
7. The egg is laid free within the empty cell.
8. Mass provisioning is practised and the provision is in the form of a pollen loaf.
9. Each nest is worked upon by a single female in any one season.
10. In *C. lichtensteinii* and *J. confusa* there is reuse of nests in successive years.
11. *Ceramius* and *Jugurtia* are in their ethology very similar.

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KEY TO LETTERING OF CELLS IN FIGS 1-5.

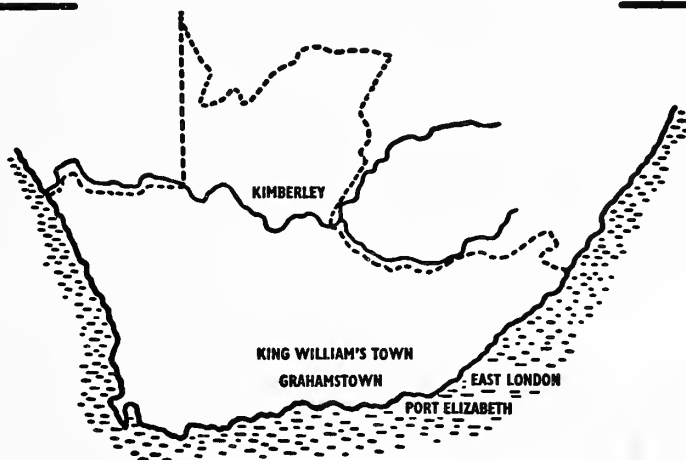
- A. Cell open, containing old cocoon from which adult wasp has emerged.
- B. Cell closed, containing pupa in cocoon.
- C. Cell closed, containing prepupa in cocoon.
- D. Cell closed, containing mature larva spinning cocoon.
- E. Cell closed, containing mature larva prior to cocoon spinning.
- F. Cell either open or closed, containing still feeding immature larva.
- G. Cell either open or closed, containing egg with provision.
- H. Cell open, containing egg without provision.
- I. Cell open, empty.
- X. Cell either open or closed, development of young aborted.



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Prey and nesting sites of some sympatric species of *Cerceris* (Hymenoptera: Sphecidae) with a review and discussion of the prey diversity of the genus

by  
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ABSTRACT

Nineteen sympatric *Cerceris* species are examined in relation to frequency of occurrence, nature of nesting sites and of prey. Their nesting sites and prey are discussed in relation to their ecological displacement. There follows a review and discussion of the prey diversity of the genus *Cerceris* which puts forward the hypothesis that *Cerceris* is an Old World genus and that its original prey was hymenopterous. Prey records of a total of twenty Afrotropical species are included of which twelve are new associations and three confirm previously published records.

INTRODUCTION

The genus *Cerceris* Latreille is cosmopolitan in its distribution and with over 850 known species is the largest genus of the Sphecidae. All species are ground-nesting and provision their young with insect prey.

The present paper is based upon observations of sympatric *Cerceris* species made over a period of seven years at Hilton, a farm situated 18 kilometres WNW. of Grahamstown (33°19'S., 26°32'E.) in the Albany Division of the Eastern Cape Province of South Africa.

In view of the large overall number of species and the frequency with which considerable numbers of species often occur together, both spatially and temporally, the ecological displacement of the species—that is the different ways in which the species exploit their habitat—is of great interest. Clearly of importance in such ecological displacement is specificity in such basic ethological factors as the choice of nesting site, and more particularly the choice of prey. It is

these aspects of the ethology of the *Cerceris* species at Hilton which are set forth in the present account.

This is the eighth of a series of publications covering some aspects of the ethology of solitary wasps occurring at Hilton, the climate and vegetation of which have been previously described (Gess and Gess, 1974: 191–192).

Prey records, both published and unpublished, from localities other than Hilton have been included in the account in an attempt to draw together information on the chosen prey of as many Afrotropical *Cerceris* species as possible, little having hitherto been published on the subject.

#### THE CERCERIS SPECIES PRESENT AT HILTON AND THE RELATIVE FREQUENCY OF THEIR OCCURRENCE

Nineteen species of *Cerceris* have been recorded from Hilton. Arranged in alphabetical order these are: *C. amakosa* Brauns, *C. armaticeps caffrariae* Empey, *C. diodonta diodonta* Schletterer, *C. discrepans discrepans* Brauns, *C. dominicana* Brauns, *C. erythrosoma* Schletterer, *C. holconota holconota* Cameron, *C. hypocritica* Brauns, *C. languida languida* Cameron, *C. latifrons latifrons* Bingham, *C. lunigera* Dahlbom, *C. nasidens obscura* Schletterer, *C. nigrifrons nigrifrons* Smith, *C. oraniensis* Brauns, *C. pearstonensis pearstonensis* Cameron, *C. pictifacies* Brauns, *C. ruficauda ruficauda* Cameron, *C. rufocincta polychroma* Gribodo and *C. spinicaudata spinicaudata* Cameron.

The species varied greatly in the frequency of occurrence, as reflected by catches and sightings. The most commonly met with species, in decreasing order, were *C. latifrons*, *C. languida* and *C. rufocincta polychroma*, *C. holconota*, *C. spinicaudata* and *C. pearstonensis*. Less commonly met with species were *C. nigrifrons* and *C. ruficauda*, *C. lunigera*, *C. nasidens obscura* and *C. oraniensis*. Rare were *C. hypocritica*, *C. amakosa*, *C. diodonta* and *C. pictifacies*, *C. dominicana* and *C. erythrosoma*, *C. discrepans* and *C. armaticeps*.

The flight periods of all the *Cerceris* species at Hilton fall between mid-October and mid-April.

#### IDENTIFICATION OF THE NESTING SITES

Nests belonging to ten species were located at Hilton. All were constructed in level or nearly level bare ground which was sufficiently friable to allow the females to excavate their burrows using their mandibles and legs but no water. The ground was firm though in sandy situations the firm underlying sand was sometimes overlain by a layer of loose material.

Six species were found to nest in sandy soil, two sites being particularly favoured: a sandpit (see Gess and Gess, 1980: Fig. 1) and the area adjacent to it, and a very gently sloping bank margining a car track where the latter crosses the bed of a seasonal tributary of the New Year's River. The sand, light coloured and fine grained, is derived from the weathering of Witteberg Quartzite and is of alluvial origin having been deposited upon its flood plain by the above seasonal water course.

The species found nesting in these sites were: *C. holconota* (seven nests; both in the sandpit and on the gently sloping bank where it nested in company with *Bembix albofasciata*); *C. languida* (many nests; in the sandpit in very fine sand where it nested in company with *Bembecinus braunsii* and *B. haemorrhoidalis*); *C. latifrons* (many nests; as for *C. holconota*); *C. oraniensis* (4 nests; on level ground immediately above and below the lip of the sandpit); *C. rufocincta* (several nests; in the sandpit where it sometimes nested in company with *Bembecinus braunsii* and *B. haemorrhoidalis*); and *C. spinicaudata* (three nests; as for *C. holconota*).

Four species were found to nest in disturbed clayey soil immediately adjacent to a water furrow (see Gess and Gess, 1976: Plate 2). The clayey soil, reddish-brown in colour, is derived

from the weathering of Upper Witteberg Shales previously known as Lower Dwyka Shales and referred to as such by Gess and Gess (1974: 192 and 1975: 24). Though less compacted than undisturbed clayey soil the substrate nested in by the four species was nevertheless less friable than the soil in sandy areas. The species concerned were: *C. lunigera* (1 nest); *C. pearstonensis* (1 nest); *C. ruficauda* (1 nest) and *Cerceris* sp. A (1 nest). The last listed species is unidentified owing to the unfortunate escape during the opening up of the nest of the female nest builder. Whereas it is very probable that the species was one of the nineteen recorded from Hilton, it is clear, knowing its chosen nesting substrate and prey, that it was not one of the named species recorded above as having been found nesting.

#### IDENTIFICATION OF THE PREY

The identity of the prey of thirteen of the nineteen species of *Cerceris* recorded from Hilton is known. Prey identifications for nine of these species were made at Hilton, seven of the associations having been previously unknown and the other two confirming previously recorded associations. For four of the ten species for which prey identifications were not made at Hilton information as to the nature of the prey taken is available from other sources. The *Cerceris* species are dealt with individually below.

##### *Cerceris* sp. A.

In a nest excavated on 6.xii.1974 and containing forty-one uneaten prey this species was found to have provisioned its cells solely with a 3,5–4,0 mm long metallic-green species of PTEROMALIDAE (Hymenoptera: Chalcidoidea).

##### *Cerceris erythrosoma* Schletterer

This species was not associated with its prey at Hilton but is known to provision with beetles of the family CURCULIONIDAE. Brauns (1911: 239 and 1926: 278) recorded the prey as a species of *Tanymecus*. Similarly, prey associated with females collected by Jacot Guillarmod at Mamathes in Lesotho and now in the collections of the Albany Museum consist in one instance of a 10 mm long specimen of *Tanymecus makkaliensis* Fhs. (det. G. A. K. Marshall) and in five instances of 6,8–7,6 mm long specimens of *Protostrophus* sp. near *sceleratus* H. v. S. (det. R. T. Thompson).

##### *Cerceris holconota holconota* Cameron

Six females seen transporting prey were captured, four after they had revealed their nests which were subsequently excavated to recover the prey stored in the caches. The thirteen prey obtained were representative of six families of Hymenoptera as detailed below: BRACONIDAE, ?Genus & sp. (1 female, 13.i.1975); BETHYLIDAE, ?Genus & sp. (1 female, 20.xii.1974); TIPHIIDAE, *Anthobosca* sp. (1 male, 13.i.1975), *Braunsomeria* sp. (4 males, 13.i.1975 and 1 male, 16.xi.1977), *Mesa incisa* (Cameron) (2 females, 20.xii.1974); MUTILLIDAE, *Dasylabris eunyce* (Péringuey) (1 male, 13.i.1975); FORMICIDAE, ?*Camponotus* sp. (1 winged male, 11.xii.1975); HALICTIDAE, *Lasioglossum* sp. (1 female, 20.xii.1974).

##### *Cerceris languida languida* Cameron

A female transporting prey was captured on each of the following three dates: 24.xi.1977, 10.i.1978 and 23.ii.1978. The first female was allowed to enter her nest which was subsequently excavated and yielded 32 prey from the cache. All 34 prey obtained from the three females were beetles of the family PHALACRIDAE and represented a single, 1,7 mm long, black *Olibrus* sp.

##### *Cerceris latifrons latifrons* Bingham

Females transporting prey were captured on 19.xi.1973 (1), 20.xii.1974 (1), 10.i.1975 (1),

9.xii.1975 (4), 2.xii.1977 (3) and 2.i.1978 (1). All eleven prey obtained were beetles of the tribe Hopliini, SCARABAEIDAE: MELOLONTHINAE. Two 4,4–4,7 mm long species were represented. The prey taken at Hilton agrees with that recorded by Arnold (1940: 106) for the subspecies *C. latifrons sedula* Arnold from Rhodesia, namely “an unidentified species of beetle (Hopliinae)”.

*Cerceris lunigera* Dahlbom

One female seen transporting prey on 6.xii.1974 was captured after revealing her nest. The two prey obtained from the cache in the excavated nest were bees of the family HALICTIDAE, namely *Halictus* sp. (female) and *Lasioglossum* sp. (female).

*Cerceris nasidens obscura* Schletterer

This species was not associated with its prey at Hilton but according to E. McC. Callan (*pers. comm.*) it has been found provisioning nests in Grahamstown with “small melolonthid beetles”, SCARABAEIDAE: MELOLONTHINAE. The tribe to which the beetles belong is apparently not Hopliini.

*Cerceris nigrifrons nigrifrons* Smith

This species was not associated with its prey at Hilton. However, Brauns (1926: 320) reported the prey to be beetles of the family BUPRESTIDAE, for instance *Sphenoptera* sp. in Rhodesia.

*Cerceris oraniensis* Brauns

Four females, each carrying a single prey, were captured at or near their nest entrances on 16.ii.1978. A fifth prey was obtained from the cache of a nest excavated on the same day. All the prey were beetles of the family CURCULIONIDAE and represented a single, 7,0–7,4 mm long *Protostrophus* species.

*Cerceris pearstonensis pearstonensis* Cameron

This species was not associated with its prey at Hilton but was found at other localities to provision with beetles of the family CURCULIONIDAE. At Strowan, near Grahamstown, on 30.xi.1970, a female was caught when flying with a 4,6 mm long *Protostrophus* sp. Prey associated with two females collected by Jacot Guillarmod at Mamathes, Lesotho, and now in the collections of the Albany Museum are likewise small weevils. The larger of the two, 4,4 mm long, is a *Protostrophus* sp., the smaller, 4,2 mm long, belongs to some other genus.

*Cerceris ruficauda ruficauda* Cameron

A nest of this species excavated on 10.xii.1974 was found to contain twenty-six uneaten prey, beetles of the family CHRYSOMELIDAE: CRIOCERINAE. A single 3,4 mm long blackish-bronze species was represented.

*Cerceris rufocincta polychroma* Gribodo

Eight females seen transporting prey were captured, one after it had revealed its nest which was subsequently excavated to recover the prey stored in the cache. The ten prey obtained were representative of two families of Hymenoptera as detailed below: TIPHIIDAE, *Anthobosca rufithorax* (Cameron) (1 female, 2.i.1978), *Tiphia* sp. (1 male, 13.xii.1977 and 1 male, 2.i.1978); MUTILLIDAE, *Chrestomutilla* sp. (1 male, 24.i.1978), *Dasylabroides caffra* (Kohl) (1 female !!, 13.xii.1977; 1 male, 17.i.1978; 2 males, 24.i.1978), *Psammotherma flabellata* (F.) (1 male, 20.xii.1974; 1 male, 13.i.1975).

*Cerceris spinicaudata spinicaudata* Cameron

Three females seen transporting prey were captured after revealing their nests which were subsequently excavated to recover the prey stored in the caches. The nine prey obtained were all



small bees of the family HALICTIDAE. Species of two genera were represented: *Lasioglossum* spp. (4 females representative of 3 species, 20.xii.1974; 1 female, 10.i.1975) and *Nomioides* sp. (probably *N. halictoides* Blüthgen) (4 females, 20.xii.1974).

Prey associated with two females collected by Jacot Guillarmod, one at Strowan, near Grahamstown (27.ii.1972) and the other at Mamathes, Lesotho, and now in the collections of the Albany Museum are likewise females of species of *Lasioglossum*. The present records confirm the association given by Brauns (1926: 337) who wrote: "I found it carrying *Halictus* sp. for larval food".

It should be noted that, though the genus *Halictus* occurs in southern Africa, most species at one time allocated to it are now included in the closely related genus *Lasioglossum*. Brauns' record may thus apply to either *Halictus* or *Lasioglossum*.

### PROVENANCE OF THE PREY

For some species at least it was established where the prey taken by them was to be found, therefore allowing the situation to be identified in which the wasps hunt and respond to prey of certain size and behaviour. For other species it is possible to speculate concerning the identity of the situation by using circumstantial evidence.

*Olibrus* sp. (Phalacridae) the sole prey of *C. languida* was found to be very common in the flowers of *Lasiospermum bipinnatum* (Compositae), an annual herb growing in the sandpit and elsewhere. Recorded from this plant in October and November during the first weeks of the wasp's flight period, the beetle was undoubtedly present both then and later in the summer in the flowers of other herbaceous composites as well. The flowers of species of *Senecio*, a genus of common occurrence at Hilton, were found by H. Andreae (*pers. comm.*) to be frequented by three *Olibrus* species at the Cape. The beetle is associated throughout its life with its host plant, the egg being laid in the flower and the larva feeding in the capitulum until full-grown when it bores down the stem to pupate in the ground. In European species there may be six generations in the year (Imms, 1957: 801). From the above it is apparent that *C. languida* must hunt for its prey in the flowers of Compositae, probably all small annuals like *L. bipinnatum*. The commonness of such plants and the large number of generations of *Olibrus* probably developing upon them makes possible the extended flight and nesting period—continuously from the first half of October to the beginning of March—established at Hilton for *C. languida*.

The Hopliini (Scarabaeidae) which constitute the prey of *C. latifrons* are as a tribe characteristically found in the flowers of Compositae so that this wasp may be expected to hunt in a similar though not necessarily the same situation as that pertaining to *C. languida*.

The *Protostrophus* sp. (Curculionidae) found to be the prey of *C. oraniensis* was common on the foliage of the annual herbaceous weed *Conyza bonariensis* (Compositae) during the only period, mid-February, during which this wasp was observed nesting. The beetle infested plants, growing in the sandpit, were in close proximity to the nests.

*Protostrophus*, recently monographed by Van Schalkwyk (1968) is a very commonly met with genus, the majority of the 136 recognized species being found in South Africa. The species are inconspicuous, mostly dull coloured and are unable to fly. In body length they range from 3–9mm. The beetles are apparently not restricted to any particular plants, the eggs being dropped to the ground where ever the females are feeding. The larvae lead a subterranean life, probably feeding upon decaying vegetable matter. Mass emergences of thousands of adults have been recorded when great damage may be done by their feeding on the foliage of many different plants including seedling trees. From the observed presence at Hilton of *Protostrophus* sp. on the foliage of *Conyza* and the known biology of the weevil genus it would appear that *C. oraniensis* hunts for its prey amongst foliage at no great height above the ground. It is probable that the

other two *Cerceris* species known to prey at least partly upon *Protothrophus* and occurring at Hilton, *C. erythrosoma* and *C. pearstonensis* hunt in similar situations.

The species of *Criocerinae* (Chrysomelidae), the sole recorded prey of *C. ruficauda* may be expected to occur on foliage as is characteristic for the subfamily and it is there that the wasp undoubtedly does its hunting.

For the species of *Cerceris* which hunt Hymenoptera two possible hunting situations immediately present themselves: at flowers and young growth visited by the prey for purposes of foraging for nectar or glandular exudates, or at the nests of the prey.

It was noted at the time when the nest of *C. lunigera* and those of *C. spinicaudata* were excavated that they were situated in close proximity to the nests of various small bees some of which at least were those of species represented amongst the prey of the wasps. This was particularly striking with respect to *C. spinicaudata* and *Nomioides* sp. (probably *N. halictoides*) which nested next to one another in the sand. It therefore seems possible that the hunting of these two *Cerceris* species may take place at or near the nest entrances of their prey and in close proximity to the entrances of their own nests. The fact that only female bees are recorded as prey would lend support to this hypothesis. The latter would be in accord with the findings of Marchal (1887) as reported by Hamm and Richards (1930: 106) on the behaviour of *C. rybyensis* (L.) (= *C. ornata* Fabr.) in France. That wasp nested in a garden path in close proximity to innumerable nests of *Andrena* and *Halictus* on which species it was preying. The *Cerceris* was reported to circle round the nests, every now and then dropping to the ground, or even entering a burrow. Only bees returning home laden with pollen were attacked, and these were knocked down and stung as they hovered over their nests before entering.

With respect to *C. holconota* and *C. rufocincta polychroma* on the other hand, the wide range of unrelated prey of both sexes and of very diverse habits and behaviour makes it likely that the only situation in which these *Cerceris* species in hunting would meet all the prey species would be at flowers and young growth to which the latter would go for foraging purposes. In the areas in which the two *Cerceris* species nested—in and near the sandpit—the flowering plants known to have been visited by a mixed company of Braconidae, Tiphiidae, Mutillidae and others were *Selago corymbosa* (Selaginaceae) and various low-growing Compositae including *Helichrysum* and *Lasiospermum*. It therefore appears that *C. holconota* and *C. rufocincta polychroma* hunt for their prey on and around flowers of low-growing herbaceous plants.

#### DISCUSSION OF THE NESTING SITES AND THE PREY IN RELATION TO ECOLOGICAL DISPLACEMENT.

The existence at Hilton of two basically very different soil types, one clayey and the other sandy, and the specificity shown by the wasps in their choice of nesting substrate has resulted in the *Cerceris* species of that locality being divided for the purposes of nesting into two distinct non-competitive groups, indicating that an area with more than one type of friable soil can support a larger number of *Cerceris* species than one with a uniform soil type.

Other factors, for example the depth of the friable soil, will be limiting. The species nesting in sand place their caches at depths ranging from  $60 \pm$  mm in *C. rufocincta* to  $500 +$  mm in *C. latifrons*. Therefore, whereas *C. latifrons* can only nest in relatively deep sand *C. rufocincta* and other shallow-nesters are less restricted.

Hunting by *Cerceris* species at Hilton appears to take place at no great distance from the nest. This being so, competition for prey between species such as for example the clay-nesting *C. lunigera* on the one hand and the sand-nesting *C. spinicaudata* on the other is avoided as, although both hunt halictine bees, their hunting areas are distinct. This is especially true for these species which are believed to prey upon bees nesting in close proximity to their own nests.

All the species are highly prey specific with the exception of *C. rufocincta* and more

particularly *C. holconota* which, with their recorded prey representing respectively two and six families of Hymenoptera, appear to be catholic in their choice. With the high prey specificity generally shown competition for prey is effectively avoided despite the fact that a number of species nesting in the same soil type may hunt in very similar situations. The most commonly taken prey recorded or known for *Cerceris* species occurring at Hilton are species of Halictidae and Curculionidae, notably *Protothropus* species. With respect to the three species hunting *Protothropus* weevils, differences in preferred size range of prey either alone or in conjunction with differences in substrate-determined nest situation are likely factors of importance in the avoidance of competition.

## REVIEW AND DISCUSSION OF THE PREY DIVERSITY OF THE GENUS *CERCERIS*

The most interesting aspect of the behaviour of *Cerceris* concerns the diversity of insects taken as prey by the genus and the specificity shown by individual species.

Provisioning is with adult Coleoptera or Hymenoptera, depending upon the *Cerceris* species. From data presented by Bohart and Menke (1976: 576) and by Iwata (1976: 150–151) it appears that eleven families of Coleoptera have so far been recorded as prey: Anthribidae, Bruchidae, Buprestidae, Cerambycidae, Chrysomelidae, Coccinellidae, Curculionidae, Nitidulidae, Phalacridae, Scarabaeidae and Tenebrionidae. Published records of Hymenoptera taken as prey mostly concern Apoidea.

Coleoptera appear to be the more commonly taken order and have been recorded as prey of *Cerceris* from many parts of the world. North American species of *Cerceris* provision exclusively with Coleoptera and the few records pertaining to South America concern prey of the same order. The few prey records for Australian *Cerceris* similarly concern Coleoptera. In the Palaearctic, Oriental and Afrotropical Regions of the Old World, however, there are, in addition to species provisioning with Coleoptera, a minority of species that utilize Hymenoptera. Thus the Palaearctic *C. rhybensis* (L.), *C. hortivaga* Kohl and *C. sabulosa* (Panzer) and the Oriental *C. pictiventris* Dahlbom provision with Apoidea, especially Halictidae and some in addition with Colletidae and Andrenidae.

Though Apoidea appear to be the most commonly taken non-coleopterous prey, four records of the use of Hymenoptera other than bees have been published (see Bohart and Menke, 1976: 576). In the Palaearctic, *C. stratiotes* Schletterer is believed to prey only on the chalcid, *Stilbula cynipiformis* (Rossi), a *Cerceris* species provisioning with halictid and andrenid bees was found to have also in its brood cells a species of *Psen* (Sphecidae), and a female *C. pekingensis* Tsuneki was reported to have taken a species of *Pison* (Sphecidae) into her burrow. The fourth record concerns the Oriental *C. langkasukae* Pagden which was reported carrying a species of *Hingstoniola* (Sphecidae) although her regular prey were buprestids.

The prey of eight Afrotropical *Cerceris* species has been recorded in print. On the African mainland, Curculionidae are taken by *C. chirindensis* Arnold (Arnold, 1932: 13), *C. emeryana varilineata* Cameron (Brauns, 1926: 322, as *C. varilineata* Cam.) and *C. erythrosoma* Schletterer (Brauns, 1911: 239 and 1926: 278); Buprestidae are taken by *C. nigrifrons* Smith (Brauns, 1926: 320); and Scarabaeidae are taken by *C. latifrons sedula* Arnold (Arnold, 1940: 106, as *C. sedula* Arnold). On Malagasy, Curculionidae are taken by *C. clypearis* Saussure; Chrysomelidae and Buprestidae by *C. albotegula* Arnold; and nomiine bees (Halictidae) by *C. nenitra* Saussure (all Arnold, 1945: 23, 41 and 42 respectively).

Additional records (all C. F. Jacot Guillarmod's and unpublished) obtained from the Albany Museum collections concern *C. bothavillensis* Brauns and *C. emeryana multicolor* Arnold (both from Mamathes, Lesotho) and *C. multipicta fuscifacies* Empey (from the Transvaal Lowveld) all of which took Curculionidae, in the case of the first named species, *Leurops sublineata* Marshall.

With the addition of the records from Hilton, the prey of a total of 20 (i.e. 10.6%) of the 189

Afrotropical species of *Cerceris* recognized by Empey (1969) is known. The corresponding figures for America north of Mexico are 21 (i.e. 27%) of 78 species (see Scullen, 1965 and Evans, 1971: 509). Of the twenty Afrotropical species concerned, fourteen species prey upon Coleoptera and six upon Hymenoptera whereas, as previously noted, all North American prey recorded comprised Coleoptera. With respect to both regions the most commonly taken prey are species of Curculionidae, 40% and 48% of the species for which prey is known taking this family in the Afrotropical Region and in America north of Mexico respectively.

*Cerceris* is most unusual though not unique (see *Bembix*) in the Sphecidae in provisioning with prey belonging to more than one order, with, as has been shown, a majority of species utilizing Coleoptera and a minority utilizing Hymenoptera. It is therefore of interest to examine which of these two orders constitutes the original prey taken by the genus.

Suggested relationships within the subfamily Philanthinae based entirely upon consideration and evaluation of morphological characters of presumed phylogenetic value have been discussed by Bohart and Menke (1976: 557–558) and shown by them in a dendrogram (Fig. 183). On the basis of the number of advanced characters appearing in each genus, *Cerceris* is seen as a highly advanced genus, surpassed only by the North American *Eucerceris*.

If on Bohart and Menke's dendrogram are entered details of the prey for each of the included genera (unknown for *Eremiasphecium*, *Odontosphex* and *Philanthinus*) it is seen that the species of Philanthinae prey pre-eminently upon Hymenoptera and that only *Cerceris* (partly) and *Eucerceris* (wholly) prey upon Coleoptera.

It therefore appears that within the Philanthinae the use of Hymenoptera as prey is primitive or unspecialized and that the use of Coleoptera is advanced or derived. In this case *Cerceris* in its prey selection represents the transitional stage between the less advanced condition and that shown by *Eucerceris*. In this connection Pagden's record (see Bohart and Menke, 1976: 576) of *C. langkasukae* carrying a hymenopteran although her regular prey were Buprestidae may represent atavistic behaviour in time of shortage of the coleopterous prey.

The change from Hymenoptera to Coleoptera by *Cerceris* can be shown to have been advantageous for two reasons. Firstly, it enabled that fraction which made the change to avoid competition with related genera (e.g. *Philanthus*) and possibly others (e.g. *Palarus*) for hymenopterous prey, and secondly, it made available to *Cerceris* as potential prey vast numbers of species of many families belonging to an order which at least in its adult stage was not being exploited by any other wasps.

The vast possibilities opened up by the adoption of the new prey may be considered to have led to an outburst of speciation in the fraction of *Cerceris* concerned, leading to the predominance of Coleoptera-preying species over Hymenoptera-preying species and to the overall magnitude of the genus *Cerceris*, which with a total of over 850 known species (Bohart and Menke, 1976: 575) is the largest genus of the Sphecidae.

Within the range of Coleoptera preyed upon, the most commonly taken by *Cerceris* appear to be species of Curculionidae and species of this family constitute the sole prey of *Eucerceris*. The preference for weevils may be attributable to the overwhelmingly greater number of species in the Curculionidae than in other families.

With respect of those Philanthinae which utilize Hymenoptera as prey, some interesting trends relevant to the prey taken by the various genera are apparent. Thus the sole recorded prey for *Pseudoscolia* and the most characteristic prey of *Trachypus*, *Philanthus* and the Hymenoptera-preying species of *Cerceris* are species of Halictidae though species of all three latter genera may also utilize other families of bees as well as wasps of several aculeate and non-aculeate families. On the other hand prey taken by three of the four genera of the Aphilanthopsini (prey is not known for the fourth genus) consists in each case of a single genus of Formicidae.

It is clear that the genera of the Aphilanthopsini are greatly specialized in their choice of prey (as is indicated also by the presence in *Clypeadon* and *Listropygia* of an "ant clamp" formed of

the pygidial plate and the hypopygium) whereas the other genera represent the more unspecialized or primitive condition. In those species which utilize a wide spectrum of prey, the prey taken at any locality or time is probably dependant upon its abundance in the area and upon its size relative to the provisioning wasp. The frequency with which Halictidae are taken by species of *Trachypus*, *Philanthus* and the Hymenoptera-preying *Cerceris* species is undoubtedly due to the commonness of species and individuals of this bee family. There does, however, appear to be a tendency towards restriction in the range of prey taken. This may be seen in those of the Hymenoptera-preying *Cerceris* occurring at Hilton for which a number of prey records is available. Thus, in contrast to *C. holconota* for which six families including Halictidae are recorded as prey, *C. spinicaudata* appears to be restricted to Halictidae and *C. rufocincta polychroma* appears to specialize in Tiphiidae and Mutillidae.

Finally, from the fact that both Hymenoptera- and Coleoptera-preying species of *Cerceris* occur in the Old World but only Coleoptera-preying forms occur in the New World it may be speculated that *Cerceris* was originally an Old World Genus.

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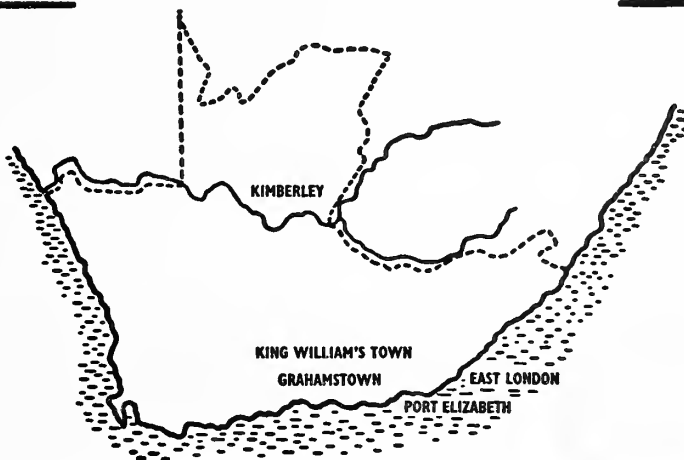


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Some aspects of the ethology of *Dasyproctus westermanni* (Dahlbom)  
(Hymenoptera: Sphecidae: Crabroninae) in the Eastern Cape Province of  
South Africa

by  
F. W. GESS  
(Albany Museum, Grahamstown)

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ABSTRACT

Some aspects of the ethology of *Dasyproctus westermanni* (Dahlbom) are described. Of particular note is the orientation of the pupae which appears to be governed by gravity rather than the position of the nest entrance. Foraging records are given for *D. bipunctatus* Lep. & Brullé, *D. dubiosus* (Arnold), *D. immitis* (Saussure), *D. ruficaudis* (Arnold) and *D. westermanni* (Dahlbom). The ethology of the genus *Dasyproctus* is reviewed and discussed.

INTRODUCTION

Sixty-seven species of the genus *Dasyproctus* Lapeletier and Brullé (Sphecidae: Crabroninae) are listed by Bohart and Menke (1976:419) of which just over half occur in the Afrotropical Region. The remainder are known from the Oriental and Australasian Regions. Published biological accounts varying from fragmentary to fairly extensive pertain to six species:

*D. agilis* (F. Smith) and *D. buddha* (Cameron) from the Oriental Region and *D. barkeri* (Arnold), *D. bipunctatus* Lep. & Brullé, *D. kibonotensis* Cameron and *D. stevensoni* (Arnold) from the Afrotropical Region.

The present paper is an account of some aspects of the ethology of a seventh species, *D. westermanni* (Dahlbom) and is the ninth in a series of publications dealing with the ethology of certain solitary wasps occurring at Hilton, a farm situated 18 kilometres WNW. of Grahamstown (33° 19'S., 26° 32'E.) in the Albany Division of the Eastern Cape Province of South Africa.

In all, five species of *Dasyproctus* have been recorded from Hilton. These are: *D. bipunctatus* Lep. & Brullé, *D. dubiosus* (Arnold), *D. immitis* (Saussure), *D. ruficaudis* (Arnold) and *D. westermanni* (Dahlbom). With respect to *D. bipunctatus* three colour forms are present which by some authors (e.g. Leclercq, 1958) are accorded subspecific rank: *D. b. bipunctatus* Lep. & Brullé, *D. b. lugubris* (Arnold) and *D. b. simillimus* (Smith). *D. b. simillimus* (Smith) is listed as a good species by Bohart and Menke (1976). Foraging records are given for all five species.

### DESCRIPTION OF NESTING SITES

Of the five species only *D. westermanni* was observed engaged in nesting activities. Nests were situated up off the ground within galleries hollowed out by the wasp in green subvertical pithy inflorescence stems of *Urginea altissima* (Liliaceae) growing on rising clayey ground immediately to the east of the New Year's River in dwarf karroo scrub characterised by *Pentzia incana* (Compositae) (Fig. 1).

Evidence of nesting by *Dasyproctus* was also found in the inflorescence stems of two species of *Gasteria* (Liliaceae) and in the stems of *Berkheya decurrens* (Compositae), all growing on clayey soil in various situations within thorn scrub. As the nests examined in these plants were all old ones from which the wasps had emerged it was not possible to establish the identity of the builders. It is possible, however, that these were the nests of one or more of the other species of *Dasyproctus*.

### FLIGHT PERIOD

The flight periods of all five species at Hilton and elsewhere in the vicinity of Grahamstown fall largely between the beginning of October and the end of March though isolated individuals have been found both earlier and later in the summer. *D. westermanni* is known from November to mid March and was found nesting in *Urginea* at Hilton during December and January.

### FLOWERS AND YOUNG GROWTH VISITED BY ADULT WASPS

At Hilton two species of *Dasyproctus* were collected on the yellow flowers of *Acacia karroo* (Leguminosae): *D. b. bipunctatus* (6.i.1977, 1 female and 13.i.1977, 1 male) and *D. dubiosus* (29.xii.1976, 2 males and 6.i.1977, 1 male). The young foliage of *A. karroo* was visited by *D. westermanni* (6.xii.1976, 1 female).

At Strowan, a farm lying between Hilton and Grahamstown, the yellow flowers of *Berkheya heterophylla* (Compositae) were visited by *D. b. bipunctatus* (12.x.1972, 4 females, 16.x.1972, 4 females, and 25.x.1972, 7 females) and by *D. b. simillimus* (16.x.1972, 1 female); at Belmont Valley, lying 25 kilometres SE. of Hilton, the yellow flowers of *Foeniculum vulgare* (Umbelliferae) were visited by *D. b. bipunctatus* (26.i.1970, 1 female), by *D. b. simillimus* (26.i.1970, 1 female, 5.ii.1970, 1 female, 28.iv.1970, 1 female), by *D. dubiosus* (20.i.1970, 1 male), by *D. immitis* (25.i.1970, 1 female) and by *D. ruficaudis* (20.i.1970, 1 female); at the Koonap River



Fig. 1. Hilton, 4.i.1978. Inflorescences of *Urgenea altissima* (Liliaceae) in dwarf karroo scrub characterised by *Pentzia incana*.

near Adelaide, 70 kilometres N. of Hilton, the greenish-yellow flowers of *Zizyphus mucronata* (Rhamnaceae) were visited by *D. b. bipunctatus* (1 female) and by *D. immitis* (1 male) (both 20–22.xii.1972).

#### IDENTIFICATION OF THE PREY

Prey was obtained only from *D. westermanni* and as in all species of *Dasyproctus* consisted of small flies. It appears that *D. westermanni* is an opportunist with respect to the flies it utilizes as prey and may take any suitably sized fly which it finds in its hunting area. All cells in which prey flies were in a condition allowing identification were found to have been provisioned with several species of flies though in some the preponderance of one or other species indicated that the wasp may, upon finding a ready supply of that species, have concentrated upon it or upon its source.

Seven dipterous families were represented amongst the prey found in nests examined during January, 1978. Details are listed below.

Simuliidae		
<i>Simulium</i> sp.	2,0 mm long	13 females, 4 males
Stratiomyidae		
1 sp.	5,2 mm long	10 specimens
Bombyliidae		
<i>Bombylius delicatus</i> Wied.	4,0 mm long	1 female, 1 male
1 sp. of Cyrtosiinae	1,4 mm long	3 specimens
1 sp. other	3-4 mm long	1 female, 1 male
Empididae		
1 sp.	3,0 mm long	1 male
Syrphidae		
1 sp.	3,6 mm long	1 specimen
Otitidae		
species A	2,2 mm long	3 females, 10 males
species B	2,4 mm long	1 male
Chamaemyiidae		
1 sp.	3,4 mm long	3 specimens

The presence amongst the prey of flies such as the Simuliidae and Stratiomyidae and possibly also the Otitidae may indicate that the chief hunting area of *D. westermanni* was in fairly close proximity to the nests, namely in the riverine vegetation fringing the New Year's River. Other flies such as the less commonly taken Bombyliidae were probably captured in the tract of open dwarf scrub nearer the nests and between the latter and the riverine vegetation.

#### DESCRIPTION OF THE NEST

The completed nest of *D. westermanni* consists of a circular entrance hole of 4 mm diameter bitten through the side of the green inflorescence stem of *Urginea altissima* (Fig. 2) and giving access to an ascending and a descending gallery of 4-4,5 mm bore hollowed out of the pithy centre of the stem. Both galleries are divided serially into a number of cells (Figs 3a, b, c and d).

A total of twenty-two nests of *D. westermanni* within nineteen subvertical stems was examined. Seventeen of the utilized stems each contained a single nest, one stem contained two nests and another contained three nests. The entrance hole to the nest was situated from 500-1 070 mm (average 770 mm) above the ground and in all but one instance was sited below the level of the lowermost elements of the cylindrical raceme which occupies the terminal two-fifths of the inflorescence stem. Heights above the ground of the bottom and the top of the raceme ranged from 820-1 360 mm (average 1 040) and from 1 550-2 100 mm (average 1 800 mm) respectively.

Of the twenty-two nests, twenty had completed ascending galleries and of this latter number nine had in addition completed descending galleries. The ascending galleries ranged in length from 42-114 mm (average 86 mm) and the descending galleries ranged in length from 78-122 mm (average 91 mm).

In length the serially arranged cells including the pithy plug sealing each ranged from 8-14 mm (average of 71: 11,2 mm), the thickness of the plugs or cell partitions being 1,5-2,0 mm. The number of cells in fully utilized ascending galleries ranged from five to eight; the only fully utilized descending gallery found contained seven cells. The maximum number of cells found in any one nest (the only one which had both galleries fully utilized and intact) was fourteen.



Fig. 2. Hilton, 4.i.1978. Portion of inflorescence stem of *Urgenea altissima* (Liliaceae) showing entrance hole of nest of *Dasyproctus westermanni* (x circa 0,5).

Neither gallery is filled with cells right up to the level of the entrance hole, the plug of the outermost cell in each case being some distance removed from it. In the above fourteen-celled completely utilized nest a vestibular space, 16 mm in length, was left between the two outermost cells. The nest entrance opening into this vestibule was not sealed.

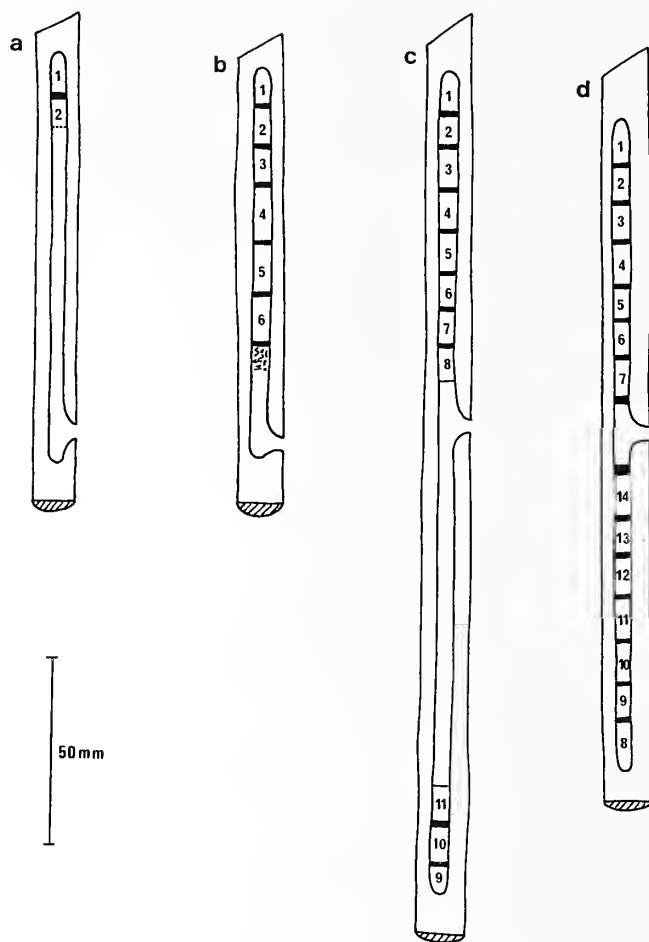
#### METHOD OF CONSTRUCTION OF THE NEST, OVIPOSITION AND PROVISIONING

A nest entrance hole having been bitten through the wall of the inflorescence stem and the pith centre having been reached, the wasp hollows out its galleries by biting off and removing the pith. Some at least of this pithy material appears, however, to be retained within the nest for the purpose of constructing the cell partitions.

The ascending gallery is invariably the first to be hollowed out and only after the full number of cells destined for this gallery has been constructed within it is a start made with the hollowing out of the descending gallery (Figs 3a, b, c and d).

Each cell is provisioned with a relatively large number of prey which are closely packed and are orientated to face the inner (i.e. blind) end of the cell. The prey is alive but partially paralysed. Two fully provisioned and sealed cells, the contents of which had neither been consumed nor had become mouldy, contained fourteen and twenty-six flies respectively.

It is not clear on which prey, in order of provisioning, oviposition takes place but it appears not to be on the first. A *D. westermanni* egg was found in each of the above two cells—in the first it was attached to a *Bombylius delicatus* Wied. (4 mm long male), one of the first three prey



Figs 3a, b, c, and d. Plans of nests of *Dasypoctus westermanni* in inflorescence stems of *Urginea altissima* in longitudinal section.

to be introduced into the cell; in the second it was attached to an Otitid (2,4 mm long male) situated about in the middle of the cell. Two partially provisioned and still open cells containing three and ten prey respectively were found in which no egg had yet been laid.

The egg of *D. westermanni* is white, very strongly curved and 1,9 mm in length. It is glued to the underside of the prothorax of the fly anterior to the legs—that is more or less in the neck region, the fly's head being pushed forwards to accommodate the anterior end of the egg in the space between the prothorax and the underside of the head. The egg extends laterally or postero-laterally across the ventral surface of the fly to either left or right. The newly hatched larva is orientated in the same way (Fig. 4).

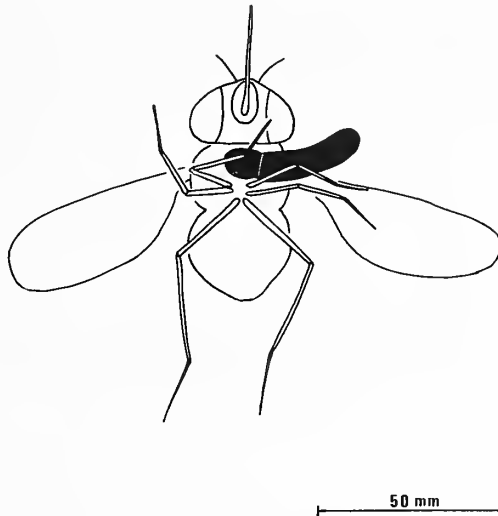


Fig. 4. Diagrammatic representation of bombyliid fly showing position of newly hatched feeding larva of *Dasyproctus westermanni*.

#### LIFE HISTORY

Due to the fact that in the nests examined all but two of the completed cells contained either provision and wasp young that had gone mouldy or cocoons containing spinning larvae or pupae, little information concerning the life history of the species could be obtained. The two eggs found on prey on 4.i.1978 and 10.i.1978 hatched on 5.i.1978 and 14.i.1978 respectively. Neither larva survived.

All twenty-six male and thirteen female wasps reared from the examined nests emerged during the period 10–27.i.1978. Development from egg to adult appears to be very rapid in the generation reared in *Urginea* stems, probably owing to the short time during which these stems are suitable for the nesting of *Dasyproctus*. It is probable that there is at least one other annual generation of the species but its nesting site has not been identified.

The silken cocoon of *D. westermanni* is brown and papery, 9 mm long and with a maximum width of 3,4 mm. Its anterior end is rounded whilst the posterior end has incorporated in it the

dark brown meconium voided by the post-spinning larva. Adhering to the meconium at the hind end of the cocoon are the prey remains—wings, legs and other uneaten fragments which the mature larva on cleaning the cell prior to the start of cocoon spinning has concentrated behind it at one end of the cell.

The orientation of the cocoons and of the pupae within them is unusual and of interest in *D. westermanni* in that it appears to be governed by gravity rather than by the position of the nest opening as indicated to the spinning larva by the curvature of the cell partitions. Thus in all cells, whether constructed in ascending or descending galleries, the anterior end of each cocoon is orientated upwards, facing away from the ground. Thus in the first-constructed ascending gallery the anterior end of each cocoon is directed away from the nest entrance and the meconium and prey remains are between each wasp and the outer partition of its cell. In the later-constructed descending gallery, however, the orientation normally practised by wasps nesting serially in tubes is present—the anterior end of each cocoon is directed towards the nest entrance and the meconium and prey remains are between each wasp and the inner or blind end of its cell.

#### PARASITES AND OTHER ASSOCIATED INSECTS; MOULD

Three distinct categories of associated insects occur in *D. westermanni* nests: a parasitoid of *D. westermanni* itself, a species cleptoparasitic with respect to the stored provision, and at least one species possibly cleptoparasitic with respect to the nest galleries.

A 4.2 mm long dark metallic green and reddish bronze *Perilampus* sp. (Hymenoptera: Chalcidoidea: Perilampidae) was found to be a parasitoid in nine cells distributed over five nests studied during January, 1978. Previously, during the summer of 1974 two specimens of the parasite were reared from the same host. The *D. westermanni* larva is attacked after it has spun its cocoon in the normal manner but before it has changed into a pupa. Each parasitized *D. westermanni* cocoon yields a single perilampid. The emergence of the adult parasitoid from the host cocoon is timed to coincide within a few days with the emergence of adult *D. westermanni* from adjacent cells in the nest.

A 2.6 mm long yellowish-brown species of Phoridae (Diptera) was found to be a cleptoparasite in one nest. When opened on 18.i.1978 it was found that in both the ascending and descending galleries all the cell partitions, bar those sealing the two outermost cells (i.e. those closest to the nest entrance), had been broken down and that the provision stored in the breached cells had been almost completely devoured. In the ascending (older) gallery the cleptoparasites had already pupated, thirteen puparia being cemented in a group to the gallery wall at the end nearer the nest entrance. In the descending (newer) gallery were twenty-four as yet unpupated maggots. These were transferred to a glass vial where they pupated on 20.i.1978. Flies from both galleries emerged from their puparia towards the end of February.

A species of *Trypoxylon* (Sphecidae) which utilizes pre-existing cavities for its nesting was found in three instances to have taken over the galleries excavated by *D. westermanni*. Though it cannot with certainty be stated that actual competition for the excavated galleries took place between *Trypoxylon* sp. and *D. westermanni* it does appear that this may have been the case and that the galleries taken over by the former were ones being used by the builder, not abandoned ones. Thus all three *D. westermanni* galleries (which were ascending ones) were either in the process of being hollowed out or of being provisioned. One of the galleries had not yet reached its final length as evidenced by the fact that its blind end had not yet been rounded off as is the case with completed galleries; the second gallery had been completed but nesting by *D. westermanni* had not yet commenced; the third gallery had had three cells completed by *D. westermanni*, the point of succession being during the provisioning of the fourth cell.

Other insects found in *D. westermanni* galleries were females of *Heriades* ?*spiniscutis* (Cameron) (Megachilidae) (three instances) and a female of *Allodapula variegata* (Smith) (Anthophoridae) (one instance). The *D. westermanni* galleries used by these bees were clearly



# ASPECTS OF ETHOLOGY OF DASYPROCTUS WESTERMANNI

abandoned ones, no recently provisioned cells being present. It is possible that the bees were merely sheltering in the galleries but it cannot be ruled out that they might have commenced nesting had they been left undisturbed. If they had, they would clearly not have been competitors for the galleries as it appears that *Trypoxylon* sp. may have been.

The previously mentioned old nesting galleries of *Dasyproctus* sp. in *Gasteria* inflorescence stems were found to have been utilized for nesting by *Trypoxylon* sp., *Heriades ?spiniscutis* (Cameron) and *Allodapula variegata* (Smith) whereas the galleries in *Berkheya decurrens* stems had been utilized by *Heriades ?spiniscutis* (Cameron) and *Allodape* sp. (*rufogastra* Lep. & Serv. or *exoloma* Strand) (Anthophoridae).

Mould attacking the stored provision is of common occurrence in the cells of *D. westermanni* and effects a larger number of cells than do parasitoids and predators together. Details are given in Table 1 of the nesting success and mortality rate due to various causes in one hundred completed cells examined.

TABLE 1.

Nesting success and mortality rate due to various causes in one hundred completed cells of *D. westermanni* examined.

Total No. of completed cells*	No. of cells attacked by mould	No. of cells attacked by Perilampidae	No. of cells attacked by Phoridae	No. of cells attacked by other insects	No. of cells in which pupae died for unknown reasons	No. of cells from which <i>D. westermanni</i> adults emerged
100	30	9	13	1	8	39

\*Excluding two cells containing newly hatched larvae which did not survive examination.

## REVIEW AND DISCUSSION OF THE ETHOLOGY OF THE GENUS DASYPROCTUS

As already noted, published biological accounts varying from fragmentary to fairly extensive pertain to six species: *D. agilis* (F. Smith) and *D. buddha* (Cameron) from the Oriental Region and *D. barkeri* (Arnold), *D. bipunctatus* Lep. & Brullé, *D. kibonotensis* Cameron and *D. stevensoni* (Arnold) from the Afrotropical Region.

*D. agilis* and *D. buddha* were both recorded nesting in stems of Gramineae (sorghum and solid dead stems of *Coelorrhachis* respectively) in which their cells were provisioned with Otitidae (mainly), Muscidae and Syrphidae and with Chloropidae and Otitidae respectively (see Bohart and Menke, 1976: 419).

Of the African species, *D. bipunctatus* Lep & Brullé (including its colour forms *simillimus* (Smith) and *lichtenburgensis* (Arnold)) is the best known. The species has been found by several observers to be restricted in its nesting to the inflorescence stems of the monocotyledonous families Amaryllidaceae, Iridaceae and Liliaceae. The most comprehensive account of the nesting of this species (*D. bipunctatus sensu stricto*) is that by Bowden (1964: 425-437) who found it nesting near Kampala (Uganda) in the flowering stems of *Kniphofia* and *Aloe* spp. (Liliaceae), *Gladiolus* sp. (Iridaceae) and *Hippeastrum* (an American genus) (Amaryllidaceae). Six families of Diptera were represented amongst the prey, namely Chloropidae, Lonchaeidae, Muscidae, Simuliidae, Sphaeroceridae and Trypetidae. Most prey were *Atherigona* species (Muscidae: Coenosiinae). On the basis of the prey taken Bowden theorized that *D. bipunctatus* forages primarily over grass. *D. bipunctatus* was also found nesting in gladiolus stems near

Salisbury (Rhodesia, now Zimbabwe) by Cuthbertson (1937: 28–31). That author listed the prey as belonging to the Anthomyiidae, Sarcophagidae, Sapromyzidae, Syrphidae and Tachinidae.

*D. bipunctatus simillimus*, in the Western Cape Province at least, appears to nest by preference in the green flowering stems of *Watsonia* sp. (Iridaceae). The present author found it nesting commonly in such stems at Kirstenbosch (Cape Peninsula) on 22.xi.1964 and A. J. Hesse of the South African Museum (unpublished notes) recorded its prey found in *Watsonia* stems at an unnamed locality as Otitidae.

It seems that the "watsonia wasp" described by Skaife (1953: 338) is referable to *D. bipunctatus simillimus* (Smith) and that the name, *Dasyproctus capensis* Skaife, given in the above publication may be considered a hitherto overlooked and therefore new synonym of the former. In the new (1979) edition of Skaife's book the revisers have come to the same conclusion concerning the identity of the wasp in question and have substituted the name *Dasyproctus bipunctatus* for *Dasyproctus capensis*.

*D. bipunctatus lichtenburgensis* at Tanga on the East African coast was found to provision its cells in stems (unspecified) almost entirely with Otitidae (= Ortalidae) and to be subject to parasitization by a species of Mutillidae (Carpenter, 1942: 48).

In contrast with the above considered species with respect to the stems utilized for nesting are *D. barkeri*, *D. kibonotensis* and *D. stevensoni* all of which utilize dicotyledonous plants.

*D. barkeri*, described from Durban, Umgeni and Malvern in Natal, was recorded by Arnold (1927: 127) as "nesting in dry stems of the Kaffir-boom" (*Erythrina* sp.) (Leguminosae).

*D. kibonotensis*, studied as was *D. bipunctatus* at Kampala (Uganda), was found by Bowden (1964: 425–437) to be restricted to the stems of *Rubus* sp. (Rosaceae) for the excavation of its nests. The prey encompassed five families, namely Lonchaeidae, Muscidae, Platystomidae, Tachinidae and Trypetidae. Most prey were *Trirhithrum coffeae* Bezzi (Trypetidae), a dominant of the dipterous fauna of robusta coffee. On the basis of the prey taken Bowden theorized that this species forages in understory shrubs. Recorded parasites were Miltogramminae.

*D. stevensoni* in West Cameroon was found nesting in a stem of *Conyza bonariensis* (Compositae) in which the cells were provisioned with Milichiidae (Michener, 1971: 407).

As far as can be established from a consideration of so relatively few species, the nesting of *Dasyproctus* appears to present great uniformity in its basic features and the nesting of *D. westermanni* at Hilton here described appears, with the possible exception of pupa orientation to be dealt with below, to be very similar to the general pattern.

All the species nest up off the ground in galleries which they themselves excavate in the pith of usually live green plant stems. The serially arranged cells are separated by pith partitions and are provisioned with numerous small adult Diptera.

In *D. bipunctatus*, *D. kibonotensis* and *D. westermanni* the nest entrance is on the side of the stem and the nest galleries proceed in both directions through the stem, the gallery directed towards the stem apex (that is the ascending gallery) being completed first in all three species. Details of the nest plans of the two Oriental species and of *D. barkeri* are not available. With respect to *D. stevensoni* it is stated that the only nest examined was damaged in its collection but that apparently the entrance was at the broken end of the stem, rather than in the side of the stem. Confirmation of this apparently unusual nest form is required.

It is in the orientation, within the galleries, of the cocoons and of the pupae within them that *D. westermanni* differs from the other two species for which the orientation has been recorded. Thus Bowden (1964: 429 and 430) recorded both *D. bipunctatus* and *D. kibonotensis* larvae as pupating with their heads towards the entrance hole of the nest. In *D. westermanni*, as already described, all pupae are orientated with their heads away from the ground and towards the apex of the flower stalk, so that only those larvae in the descending gallery have their heads towards the nest entrance.

Using the trends shown by the reviewed species some speculation is possible concerning the

identity of the builders of the old *Dasyproctus* nests found at Hilton in the inflorescence stems of *Gasteria* spp. (Liliaceae) and in the stems of *Berkheya decurrens* (Compositae). All the nests concerned had side entrances and both ascending and descending galleries. In the case of the nests in *Gasteria* it is not impossible that these were the work of *D. westermanni* but the fact that these plants were in a vegetation type different from that in which occurred the *Urginea* frequently utilized by *D. westermanni* may indicate the involvement of a different species. The nature of the inflorescence stalk utilized may indicate that *D. bipunctatus* might have been the species concerned. In the case of the nests in *Berkheya decurrens* it is probably correct to consider that they were the work of neither *D. westermanni* nor *D. bipunctatus* as all records indicate that these two species are restricted to monocotyledonous inflorescence stalks and that no species nests in both monocotyledonous and dicotyledonous plants. The nests in *Berkheya* are thus probably those of one of the other three *Dasyproctus* species recorded from Hilton, namely *D. dubiosus*, *D. immitis* and *D. ruficaudis*.

It is clearly of survival value to all species of *Dasyproctus* if the herbaceous plant stems in which they make their nests are protected in some manner or other from being eaten by large herbivores. With respect to those plants found to be utilized by *Dasyproctus* at Hilton it can be shown that all are so protected at least from the herbivores now common there, namely cattle, sheep and goats. Thus *Urginea altissima*, which grows freely exposed in the dwarf karroo scrub and which is very conspicuous when flowering on account of the long inflorescence stalks, is avoided by the above animals. This is undoubtedly due to the plant's toxicity to stock resulting from the presence in all parts of the plant of a glucoside having a digitalis action (see Watt & Breyer-Brandwijk, 1962: 717-718). It has furthermore been observed by the author that *Urginea altissima* is also left untouched under the more natural conditions of the Addo National Elephant Park where the herbivores in the portion of the park examined are buffalo, eland, hartebeest and a variety of smaller buck.

The *Gasteria* spp. at Hilton appear to be innocuous to herbivores, no indication to the contrary being found in Watt & Breyer-Brandwijk. However, these plants are found at Hilton only in the shelter of thorny shrubs such as *Acacia karroo* where they are thus physically protected from stock. *Berkheya decurrens* on the other hand grows in the open, often on disturbed ground, but is well protected from herbivores by the spinose projections of the leaves and involucre bracts.

Stems utilized elsewhere by *Dasyproctus* species may at least in some instances also be shown to be immune from destruction by herbivores. Thus the trailing stems of *Rubus* sp. (used by *D. kibonotensis*) are undoubtedly protected by the sharp prickles with which they are armed. With respect to *Watsonia* spp. (used by *D. bipunctatus*) it has been observed near Grahamstown that buck readily eat the actual flowers but not the inflorescence stalks (Jacot-Guillarmod, *pers. com.*).

It is apparent therefore that there is no consistency in the nature of the protection offered by the plants in which *Dasyproctus* nests as it may be due to their physiological or morphological nature or to their protected habitat.

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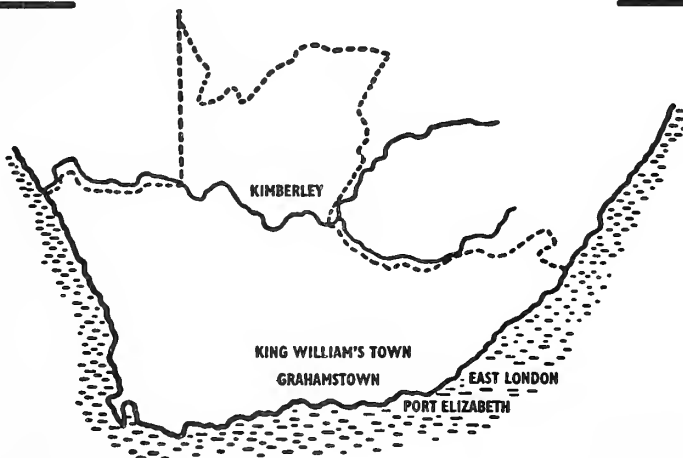
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# The distribution and status of some eagles in the Cape Province

by

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## UITTREKSEL

'n Studie van die verspreiding en digtheid van verskeie arend spesies in die Kaapprovinsie, gebaseer op 'n posopname gevolg deur 'n veldwaarheidsopname ("ground-truth survey"), word beskryf. Ondanks sekere tekortkominge verbonde aan so 'n opname, en die groot gebied wat gedek is, was dit moontlik om 'n geldige prent van die verspreiding van die betrokke spesies, so wel as realistiese beramings van hulle digtheid, te verkry. Dit was nie moontlik om verklarings te kon maak nie oor enige neigings wat miskien teenwoordig is, maar die opname het getoon dat, van die nege arend spesies wat in die Kaapprovinsie broei, is daar vyf wat blykbaar lewensvat-

bare, alhoewel klein, bevolkings het terwyl 'n sesde spesies moontlik besig is om tot uitroeiing te daal.

### ABSTRACT

A study of the distribution and abundance of some eagles in the Cape Province, based on a postal survey followed by a ground-truth survey, is described. Despite certain disadvantages attached to such a survey, and the vast area covered, it was possible to obtain a valid picture of the distribution of the species involved, as well as realistic estimates of their abundance. It was not possible to make statements on any trends that may exist but the survey indicated that, of the nine species of eagles that are known to breed in the Cape Province, five appear to have viable, albeit small, populations while a sixth species may be declining to extirpation.

### INTRODUCTION

Recently raptors have become a source of international concern as they are at the top of various food chains and consequently are important environmental indicators. The status of eagles in the Cape Province is given in general terms in Skead (1967), Winterbottom (1968) and McLachlan & Liversidge (1978). The factual basis for the statements by these authors is meagre, primarily because of the paucity of observers in a vast province. Virtually nothing is known of the status of eagles in the Cape Province and most of the work concerning eagles has been in the form of random roadside counts (Rudebeck 1963; Rowan 1964; Siegfried 1966, 1968; Cade 1969; Maclean 1970; Dean 1975a).

Despite the lack of precise information it is common knowledge that some eagles have declined in numbers and range and five species occurring in the Cape Province are considered to be vulnerable to extirpation. The decline has been attributed to decreasing food supplies, loss of habitat due to agricultural and urban development and to direct persecution (Siegfried 1963, 1968; Skead 1967; Hejl 1972; Winterbottom 1972; Siegfried *et al.* 1976; Vernon 1978; Boshoff & Vernon in prep.). For many years farmers have persecuted eagles for taking their stock. At one period, bounties were paid on eagles in the Cape Province, and there are records of nearly 5 000 bounties paid between 1930 and 1955 (Boshoff & Vernon in prep.). For example, over a seven year period, 1947 to 1953, an average of 74 bounties was paid per year in the Bedford district. In the Laingsburg district 150 Black Eagles were killed in one year (Siegfried 1963). The effects of this persecution are not known but the present authors suspect that in some areas it has caused the extirpation of the eagles.

In 1976 a survey was initiated by the Cape Department of Nature and Environmental Conservation (CDNEC) to determine the distribution and abundance of some of the eagles in the Cape Province. Eight species were included in the survey namely Black Eagle *Aquila verreauxi*, Crowned Eagle *Spizaetus coronatus*, Martial Eagle *Polemaetus bellicosus*, Tawny Eagle *Aquila rapax*, Long-crested Eagle *Lophaetus occipitalis*, Fish Eagle *Haliaeetus vocifer*, Bateleur *Terathopius ecaudatus* and Black-breasted Snake Eagle *Circaetus pectoralis*. Three species, two of which are rare and are not known to breed in the Cape Province, were omitted.

An additional aim of the 1976 Survey was to obtain information on alleged stock predation by eagles (Boshoff & Vernon in prep.).

### SURVEY METHODS

In 1976 a questionnaire was sent by the Department of Nature and Environmental Conservation of the Cape Province (CDNEC) to all farmers and landowners in the province. The questionnaire requested information about the presence, breeding and feeding of certain eagles and vultures. It was accompanied by a coloured illustration depicting those eagles and vultures,

together with a covering letter explaining the aims of the survey, and a stamped and addressed reply envelope. The information gleaned from the returned questionnaires was placed on computer and printouts of this information were made available to members of the CDNEC for the ensuing ground-truth survey. This survey was considered necessary in order to evaluate the results of the postal survey and farmers/landowners throughout the province were visited. The detailed objectives were to establish whether the species that the farmers had reported actually occurred or bred in the recorded area. Due to logistical problems it was not possible to conduct the ground-truth survey on a totally systematic basis and farms to be visited were chosen on a random basis according to proximity to the route followed. Attempts were made to include all the major physiographic regions of the Cape Province. For convenience of discussion the province was divided into six zones namely South-Western Cape (S.W. Cape), Southern Cape (S. Cape), Karoo, North-Western Cape (N.W. Cape), Northern Cape (N. Cape) and Eastern Cape (E. Cape). The boundaries of these zones are shown in Fig. 1.

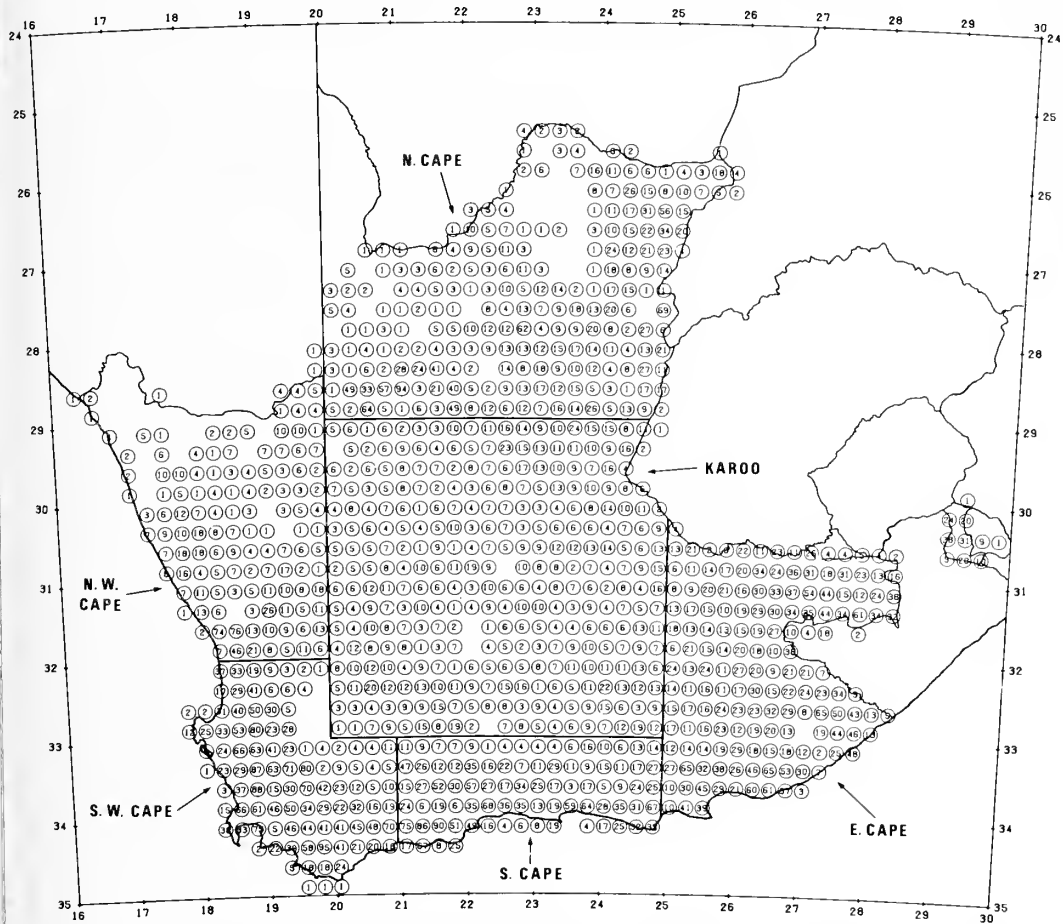


Fig. 1. Regions of the Cape Province and number of questionnaires returned per locus in the CDNEC 1976 Postal Survey.

The records of presence, which include breeding reports, of the various species of eagles and vultures were plotted according to the total number of returns per query per locus (locus = one quarter-degree square; approximately 630 sq. km). The information was arranged in four ways: presence and breeding reports or breeding reports alone, with records uncorrected or corrected. In order to compensate for misidentifications it was arbitrarily decided to reject all records of only one report per locus; this represents the "corrected" state. The authors decided that a record was most likely to be incorrect if only one farmer in a locus reported the species, taking into consideration that this may have resulted in a bias against particularly astute observers. This factor may also have favoured loci from which were received a large number of replies to the 1976 questionnaire as opposed to those loci from which there were few replies. Thus all maps reflecting the results of the 1976 Survey represent only the corrected data. The results of this survey were compared with all records that could be gathered from other sources. These include the observations of the members of the ground-truth survey and all published and unpublished records from 1970 onwards.

The abundance of four species of eagles was estimated from the breeding reports of the 1976 Survey. The actual number of reports was multiplied by the proportion of those reports that were investigated by the ground-truth survey and found to be correct. This figure was then multiplied by the reciprocal of the percentage poll to give an estimate of the total number of breeding pairs of each species in the Cape. The confidence limits, at the 95% level, based on the proportion of correct reports, were taken from tables in Diem & Lentner (1970).

Comparative estimates of abundance of the four eagle species were made from the ground-truth survey. These were based upon the tabulation of nests seen during the 1976 Survey, or found independently of the farmers, together with estimates of the numbers of potential pairs in the areas of the Cape Province not visited by members of the ground-truth survey.

The above methods of assessing abundance were made for the Cape as a whole and for each degree square (16 loci—approximately 10 000 sq. km). In the E. Cape, where several degree squares were thoroughly covered by the ground-truth survey, it was possible to make detailed comparisons between the results of the 1976 Survey and the ground-truth survey.

## EVALUATION OF THE INFORMATION OBTAINED FROM THE SURVEY

### *Distribution of farmers*

A total of 30 487 farmers/landowners was sent questionnaires of which 14 761 were completed and returned to give a poll of 48.4%. The distribution of farmers replying to the 1976 Survey is shown in Fig. 1. This map reflects the actual distribution of the farmers as the blank areas represent either non-farming areas, regions where the density of farmers per locus is low, or African states/homelands which were not covered by the survey. The average number of farmers replying to the 1976 Survey per locus was about 12, but in some loci there were none and in the intensively farmed areas there were frequently more than 50. The density was lowest in the Karoo and N.W. Cape and greatest in the S.W. Cape and S. Cape.

### *Identification of the eagles*

Although the farmers, not unexpectedly, had problems with the identification of the various eagles and vultures, the authors consider that, for persons not specifically interested in bird watching, they were very competent. Problems arose through the variety of vernacular names, the difficulties of identifying species and the pictures accompanying the questionnaires. The vernacular names caused considerable confusion, especially those linking the Black Eagle and the Bateleur, the Black Eagle and the Bearded Vulture *Gypaetus barbatus*, and the Martial Eagle and the Bearded Vulture. This problem is discussed in Boshoff (1979).

The differences between the adult and immature plumages of the eagles also provided a source of confusion. Only adult birds were illustrated in the questionnaire, and some farmers identified immatures of commoner eagles such as the Black Eagle and Martial Eagle as the Bearded Vulture, Black-Breasted Snake-Eagle or Tawny Eagle. As a result in this paper the Bearded Vulture data have been included with that for the eagles. The inclusion in the illustrations of the Bateleur but the omission of the Jackal Buzzard *Buteo rufofuscus* meant that farmers reported the Bateleur instead of the more common Jackal Buzzard. This was compounded by the fact that in some areas the buzzard is called the Bateleur.

There were consistent patterns of misidentification. The common species were more frequently correctly identified than the rarer species. The farmers' identifications and the likely species they were reporting are shown in Table 1. There was no significant difference between the rate of correct identification of the Black, Crowned, Martial and Fish Eagles, and a common correction factor is used for these species.

TABLE 1

*Identification of the eagles and the Bearded Vulture in the CDNEC 1976 Survey*

Likely identification*	Species identification by the farmers								
	B.E.	C.E.	T.E.	L.E.	F.E.	BAT.	M.E.	S.E.	B.V.
Black Eagle (B.E.)	107					26			22
Crowned Eagle (C.E.)	1	27					1		
Tawny Eagle (T.E.)			14			1			
Long-crested Eagle (L.E.)				3					
Fish Eagle (F.E.)					22				
Bateleur (BAT.)						6			
Martial Eagle (M.E.)	2	2	7			2	47	2	34
Snake Eagle (S.E.)									2
Bearded Vulture (B.V.)			1			2			
Jackal Buzzard									
Unknown	25	3	19	2	4	18	21	7	12
Number of nest reports investigated	135	32	41	5	26	55	69	9	70
% correct	79	84	33	60	85	11	67	0	3
Upper c.i. (95%)	86	95	50	95	96	22	78	34	12
Lower c.i. (95%)	71	67	20	15	65	4	55	0	1

\*According to the ground-truth survey.

### *Reports of Presence and Breeding*

The ground-truth survey proved that it was not possible to devise a method of assessing the accuracy of reports of the presence of any eagle species on individual farms. Thus while distribution maps based on these reports are given, no proper estimate can be made of their accuracy, other than the "percentage correct" data given in Table 1. The authors consider that both the presence reports and the breeding reports suffered from the above inaccuracies, but that there was a greater degree of inaccuracy in the presence reports than in the breeding reports. However, the results of the 1976 Survey pertaining to the Cape Vulture *Gyps coprotheres* indicated that the farmers reported the presence of the vultures if they had seen them on the farm at some time during their lifetime (Boshoff & Vernon 1980). Thus any distribution map based on presence records may reflect the pattern over the last generation; say twenty-five years.

In contrast to the presence reports, the breeding reports are considered to reflect the present

day situation. In addition the members of the ground-truth survey were able to assess the accuracy of breeding reports as a nest is a static object. Three classes of accuracy were established: correct, possibly correct and incorrect. The "possibly correct" records are those where the farmer could not locate the nest reported but the member of the ground-truth survey considered that there could easily have been a nest on the farm. Only the "correct" reports are used in the estimates of the abundance of individual species of eagles.

## DISTRIBUTION AND ABUNDANCE OF THE EAGLES

### Black Eagle

#### *Distribution*

The 1976 Survey indicated that the Black Eagle is widespread in the Cape Province. The distribution of farmers reporting the species on their farms is shown in Fig. 2 and indicates that

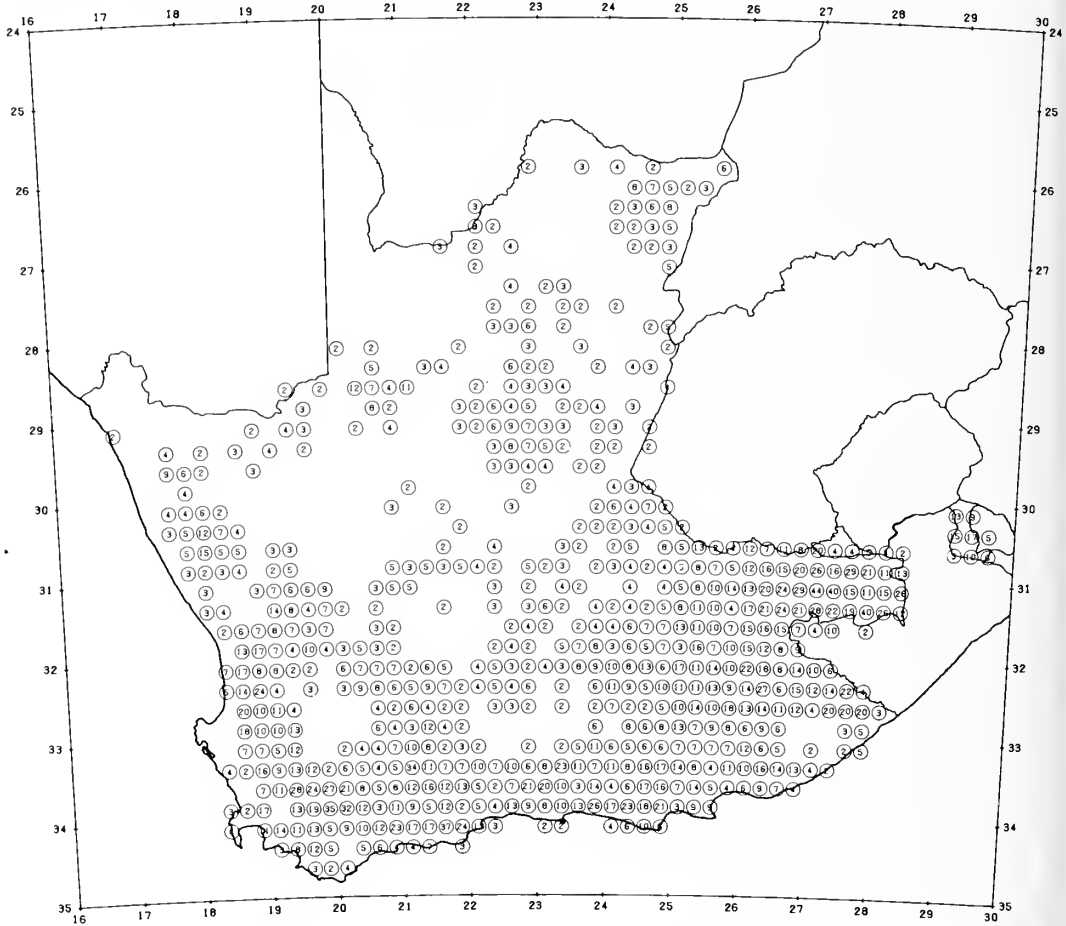


Fig. 2. The distribution of farmers reporting the presence of Black Eagles on their farms in the CDNEC 1976 Survey. Circled digits represent totals per locus.

the Black Eagle is widespread throughout the S.W., S., and E. Cape but is localised in the other three regions. The pattern of distribution of farmers reporting that Black Eagles bred on their farms is shown in Fig. 3. This map shows the same pattern as Fig. 2 but intensifies the trends to suggest that even in the southern regions the species may be absent from some areas. Fig. 3 tends to reflect the distribution of mountainous and hilly terrain, which constitutes the known habitat preference of this eagle, and compares favourably with the distribution of Black Eagle sightings obtained from other sources for the period 1970 to 1979 (Fig. 4). It should be mentioned that the concentration of reports from portions of degree squares 28 22, 29 22 and 29 23 (Fig. 3) was not investigated during the ground-truth survey (*vide* Fig. 4).

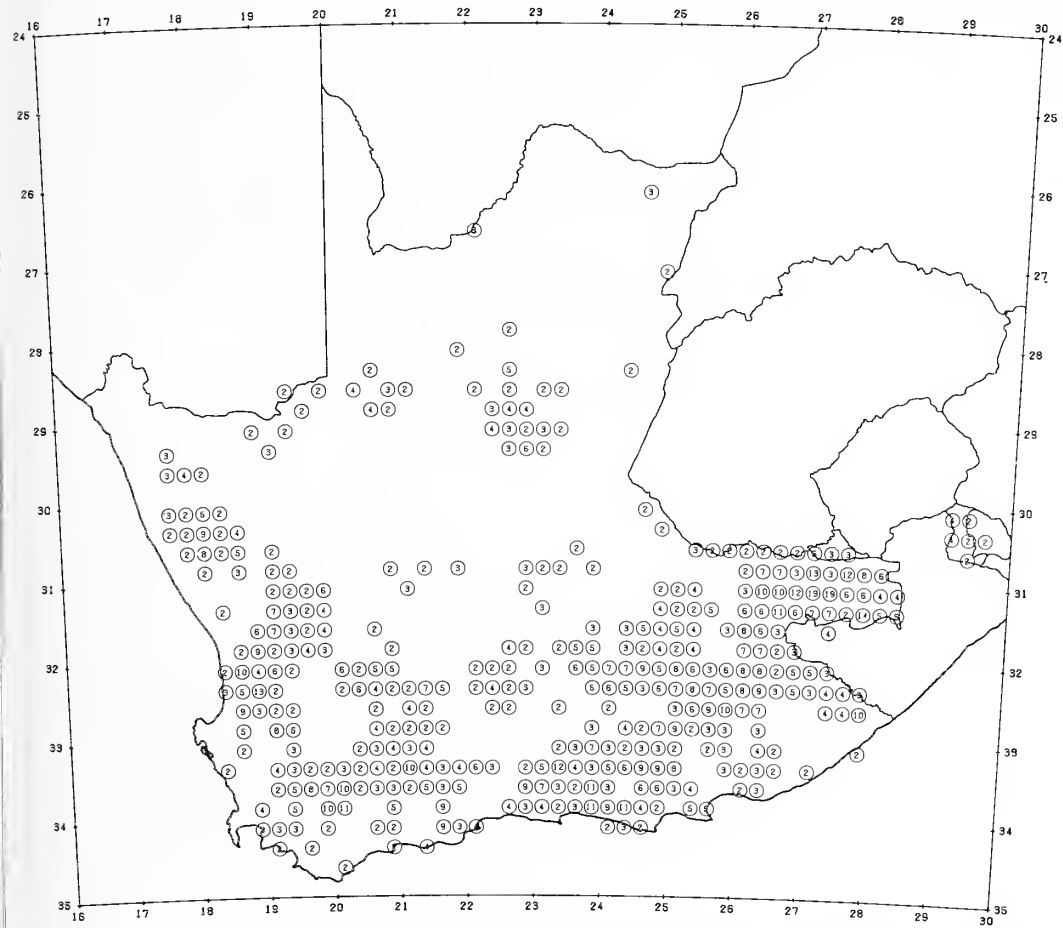


Fig. 3. The distribution of farmers reporting breeding by Black Eagles on their farms in the CDNEC 1976 Survey. Circled digits represent totals per locus.

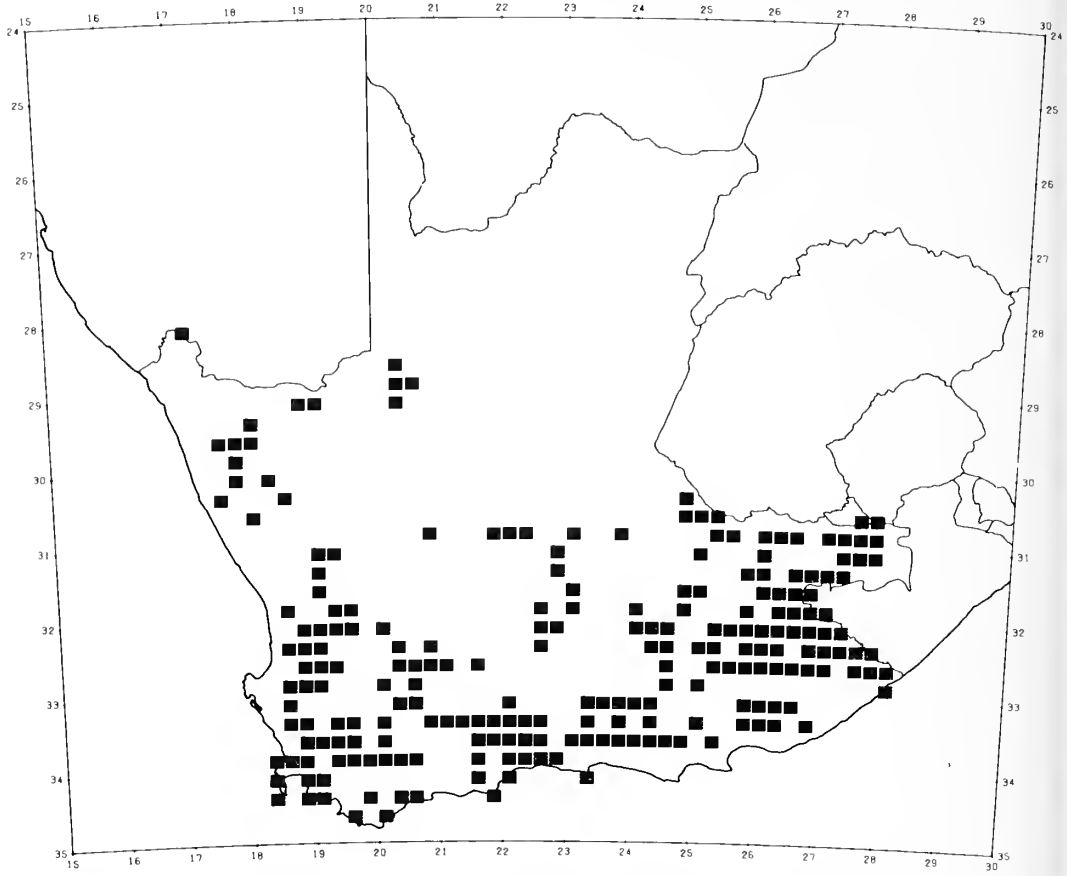


Fig. 4. The distribution of the Black Eagle according to published and unpublished records (ex CDNEC 1976 Postal Survey data) between 1970 and 1979.



The authors consider that the 1976 Survey provides an accurate picture of the distribution of the Black Eagle in the Cape Province.

#### Abundance

From the 1976 Survey it would appear that the Black Eagle is the most abundant eagle species in the Cape Province. There are an estimated 487 breeding pairs, and the potential range of this estimate is from 280 to 730 pairs (Table 2). The estimate of 487 pairs is considered to be reasonable as the ground-truth survey gave an estimate of a minimum of 400 pairs. These figures suggest that in the Cape Province as a whole the Black Eagle is about seven times more abundant than any other eagle.

TABLE 2

*Estimates of the numbers of breeding pairs of four species of eagles in the Cape Province, based on the results of the CDNEC 1976 Survey and the ground-truth survey*

	Eagle species			Fish
	Black	Crowned	Martial	
Total Farmers—30 487				
% replying—48,4				
Number reporting eagles breeding . . . . .	1 766	83	351	236
Number of breeding reports investigated . .	135 (7,6%)	32(38,6%)	70(19,9%)	26(11,0%)
Number of occupied nests found (excluding "possibly occupied") . . . . .	18	10	5	3
% investigated that were correct . . . . .	13	31	7	12
95% confidence limits				
—upper . . . . .	20	50	16	30
—lower . . . . .	8	16	2	2
Estimated number of breeding pairs* . . . .	487	54	52	56
95% c.l. on estimate				
—upper . . . . .	730	86	116	146
—lower . . . . .	280	28	17	12
Estimated number of breeding pairs extra- polated from ground-truth survey data . . .	400–500	50	?	45

\*Calculation of estimated number of pairs based on:

$$\text{e.g. Black Eagle } \frac{18}{135} \times \frac{100}{48,4} \times \frac{1\,766}{1}$$

The breeding density of the Black Eagle varies throughout the Cape Province (Fig. 5) and the birds are most abundant in parts of the N.W. Cape and the E. Cape. The greatest density is found in the degree square 32 26, which is the area between Adelaide, Bedford, Cradock and Tarkastad. Within this area V. L. Pringle reported 14 eyries of the Black Eagle in the area of one locus (circa 630 sq. km).

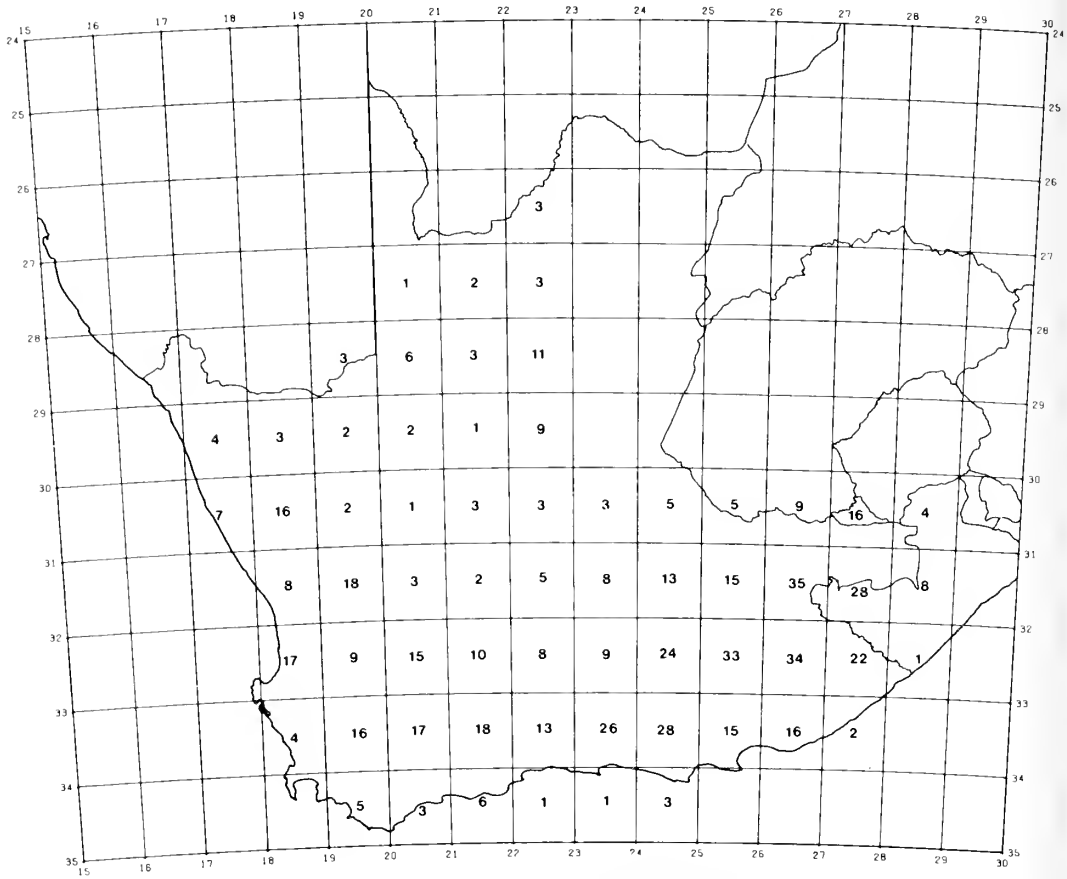


Fig. 5. The estimated breeding density of Black Eagles per degree square.

**Crowned Eagle***Distribution*

The 1976 Survey indicated that the Crowned Eagle is mainly found in the S. Cape and the E. Cape (Fig. 6) although there were isolated reports from all other regions. These records do not appear in the map of the distribution of breeding Crowned Eagles (Fig. 7). This map compares favourably with that of Crowned Eagle sightings made by observers other than farmers (Fig. 8) and the authors consider that the 1976 Survey provides a valid assessment of the distribution of the Crowned Eagle.

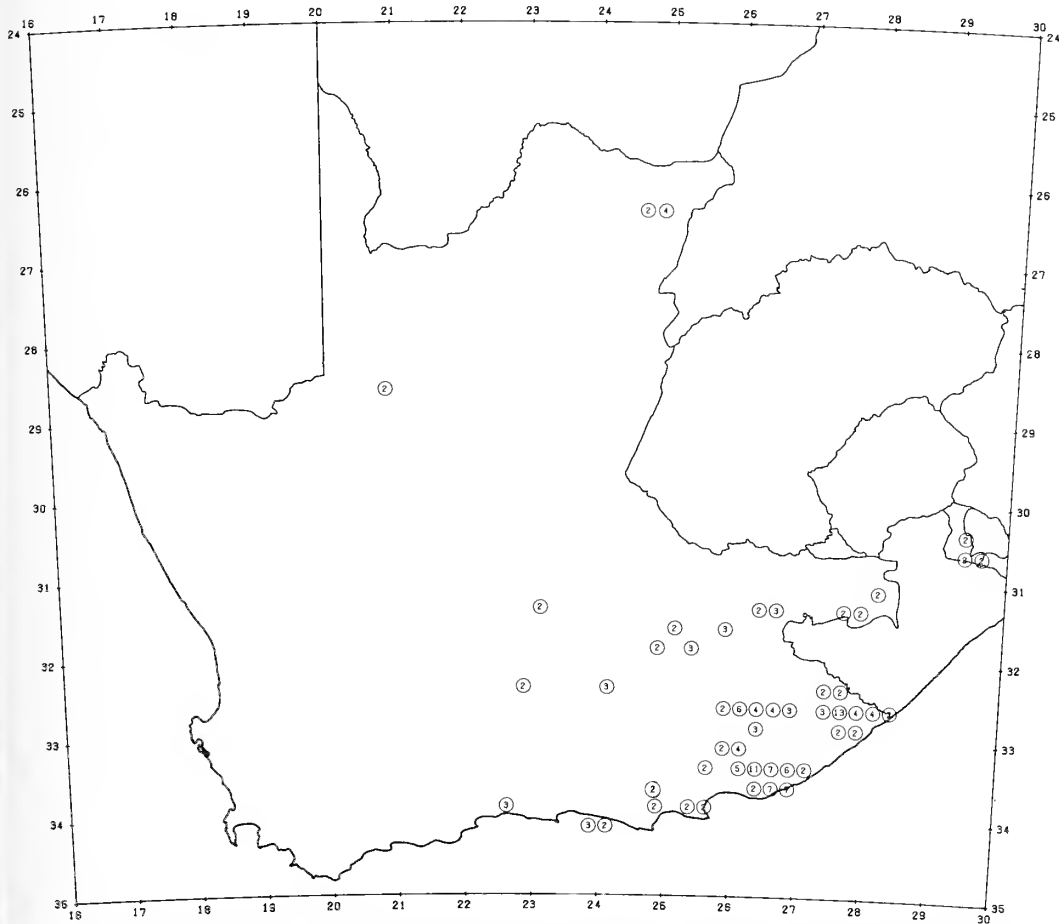


Fig. 6. The distribution of farmers reporting the presence of Crowned Eagles on their farms in the CDNEC 1976 Survey. Circled digits represent totals per locus.

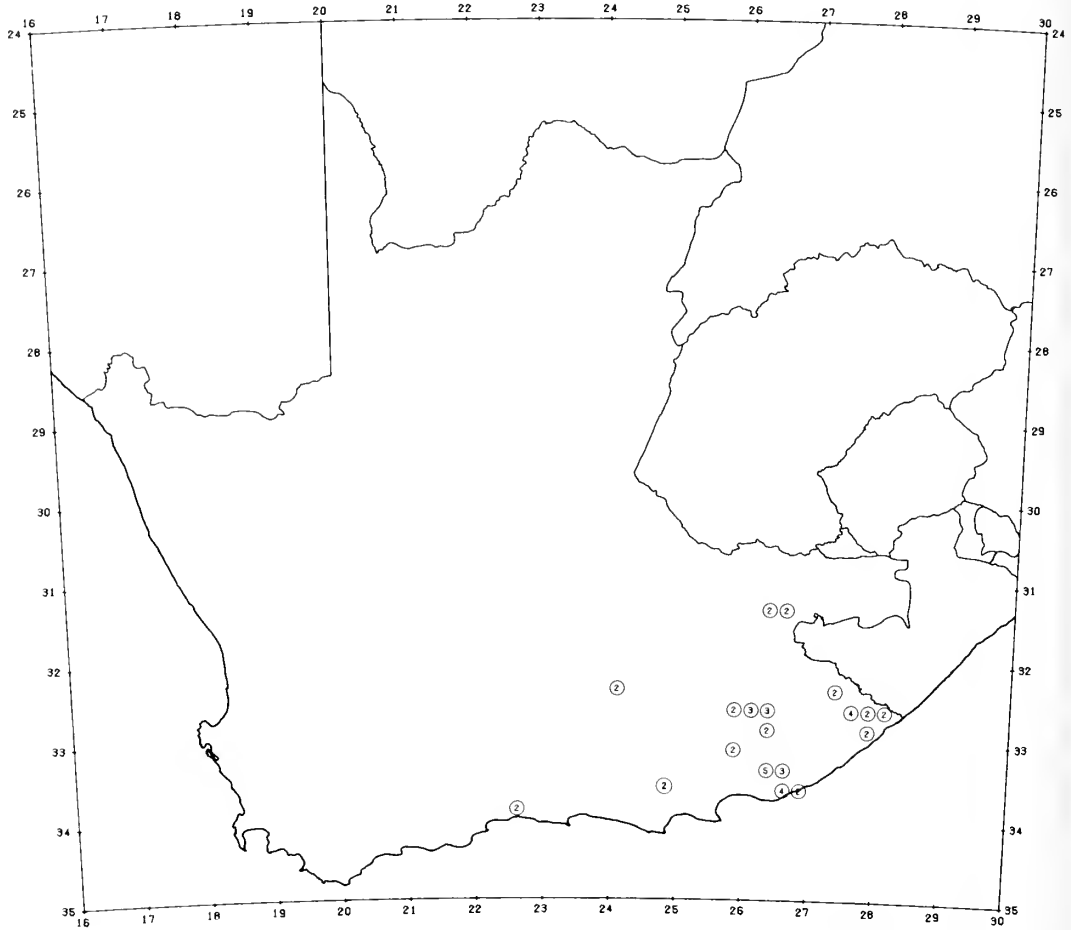


Fig. 7. The distribution of farmers reporting breeding by Crowned Eagles on their farms in the CDNEC 1976 Survey. Circled digits represent totals per locus.

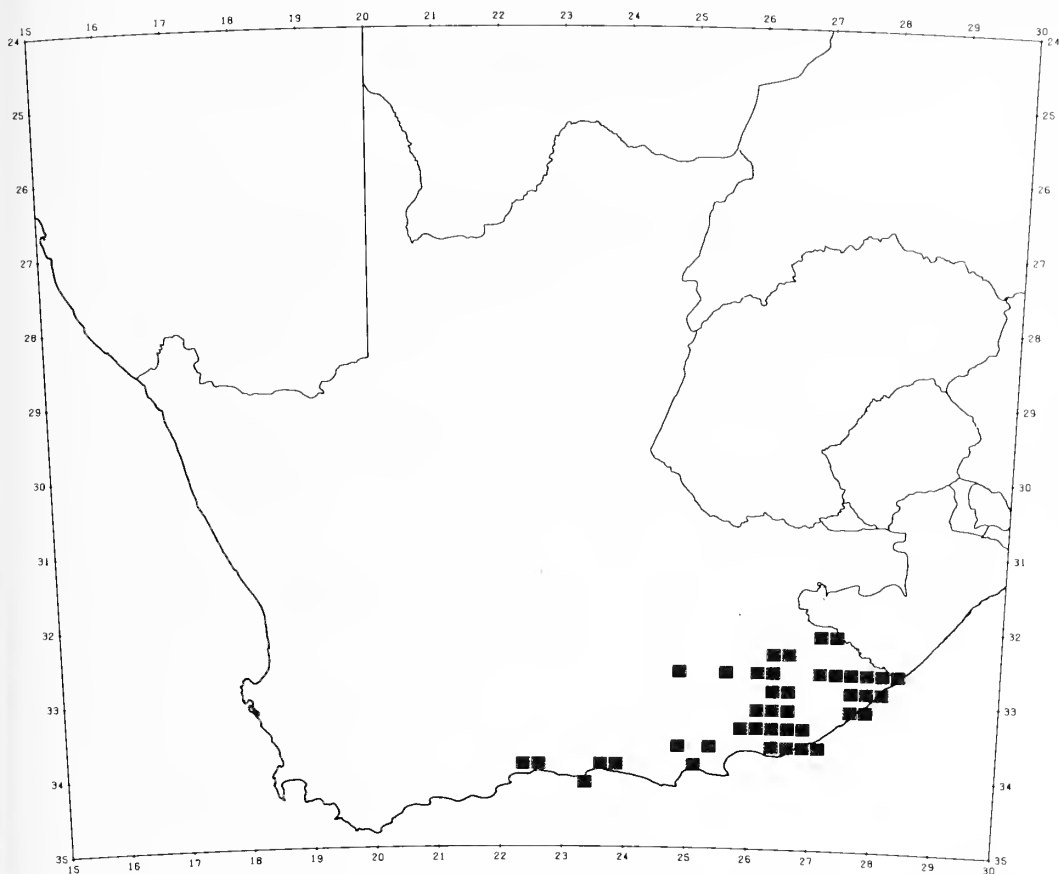


Fig. 8. The distribution of the Crowned Eagle according to published and unpublished records (ex CDNEC 1976 Postal Survey data) between 1970 and 1979.

### *Abundance*

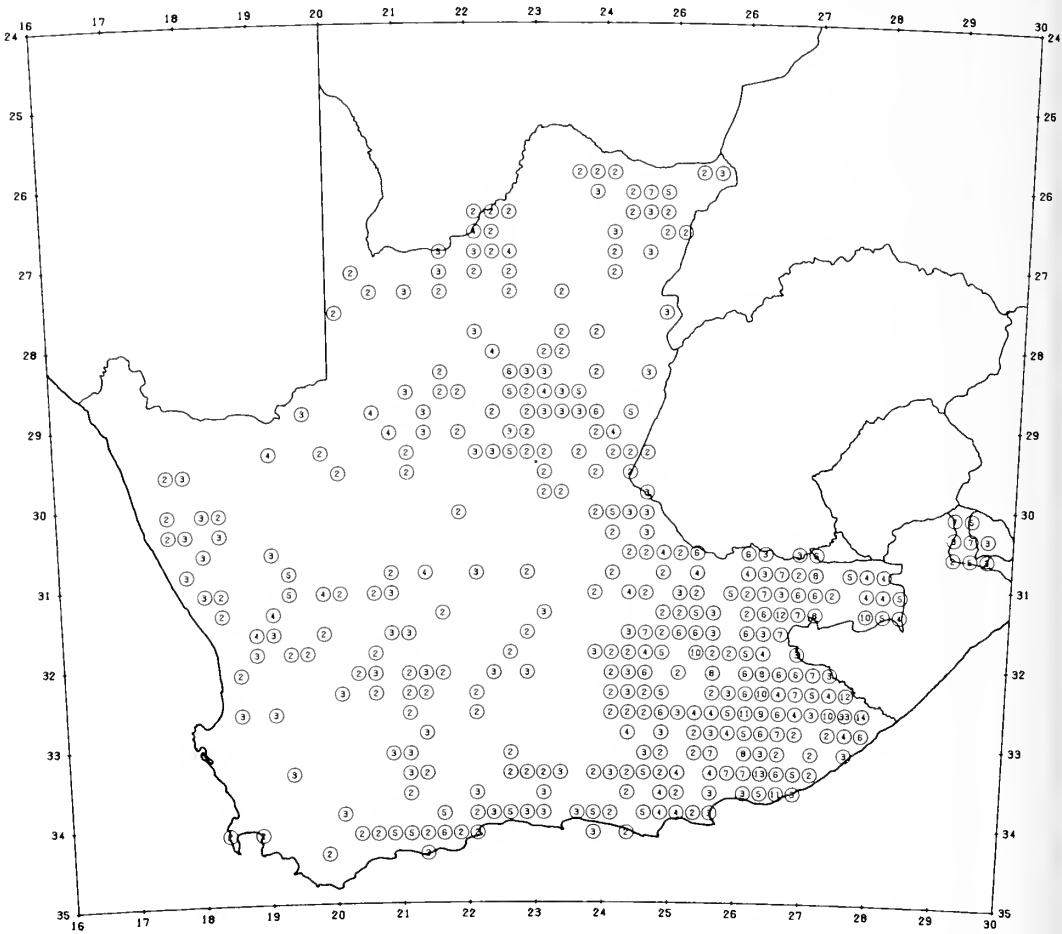
Estimates from the 1976 Survey suggest that there are 54 pairs of Crowned Eagles in the Cape Province. The range of this estimate is between 28 and 86 pairs (Table 2). The ground-truth survey tabulated 50 eyries of the Crowned Eagle but not all of these were checked during the 1970s to see if they were still occupied. It is considered that the number of these that have been abandoned may be compensated for by eyries that have not been located, and that 50 breeding pairs is a reasonable estimate.

The density of Crowned Eagles is variable within the E. Cape and the 1976 Survey correctly identifies the areas of greatest density. Crowned Eagles are known from the ground-truth survey to be most numerous in the degree squares 32 26, 32 27 and 33 27 indicated in Fig. 7; these are the Bedford, Komga and Grahamstown districts.

## Martial Eagle

### *Distribution*

The 1976 Survey indicated that the Martial Eagle is widespread in the Cape Province (Fig. 9). This eagle is found throughout the E. Cape but is more localised in other regions. The extent of the localisation is emphasised in the map of the breeding distribution of the Martial Eagle (Fig. 10). These results compare favourably with the distribution of Martial Eagle records made by other observers (Fig. 11).



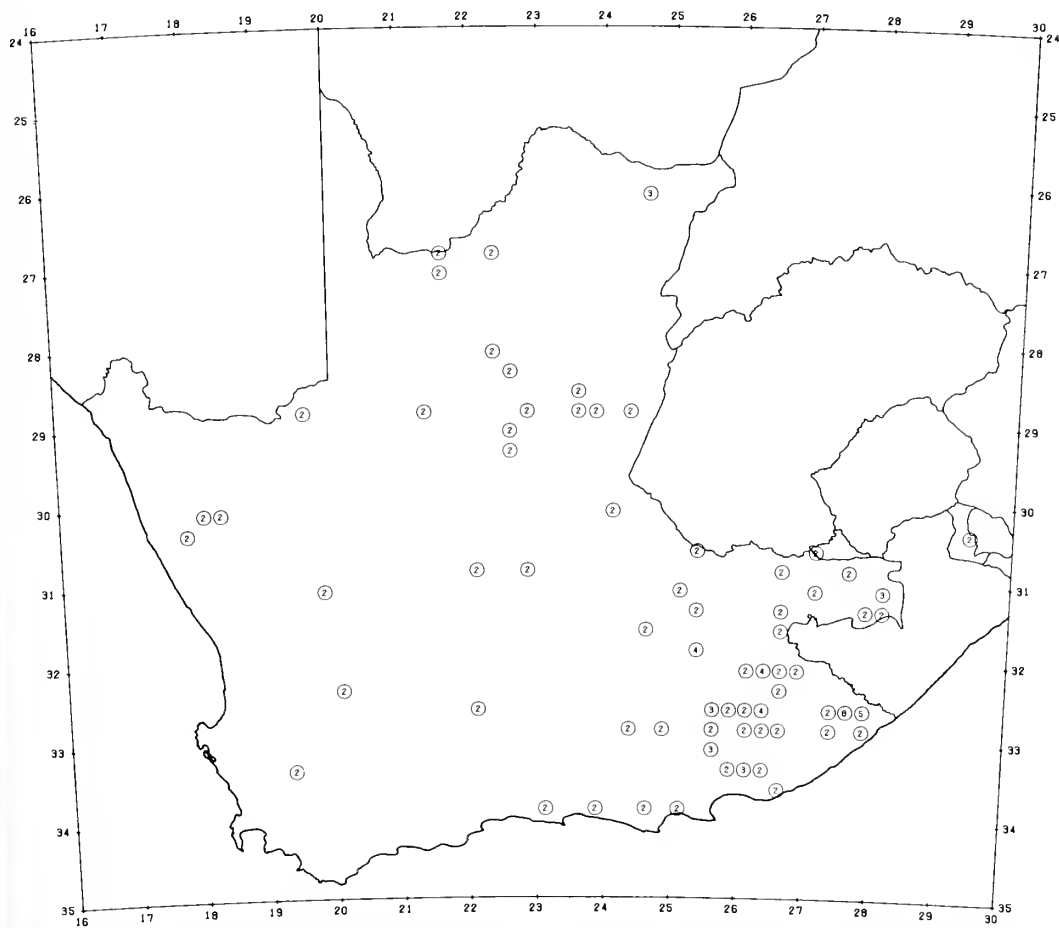


Fig. 10. The distribution of farmers reporting breeding by Martial Eagles on their farms in the CDNEC 1976 Survey. Circled digits represent totals per locus.

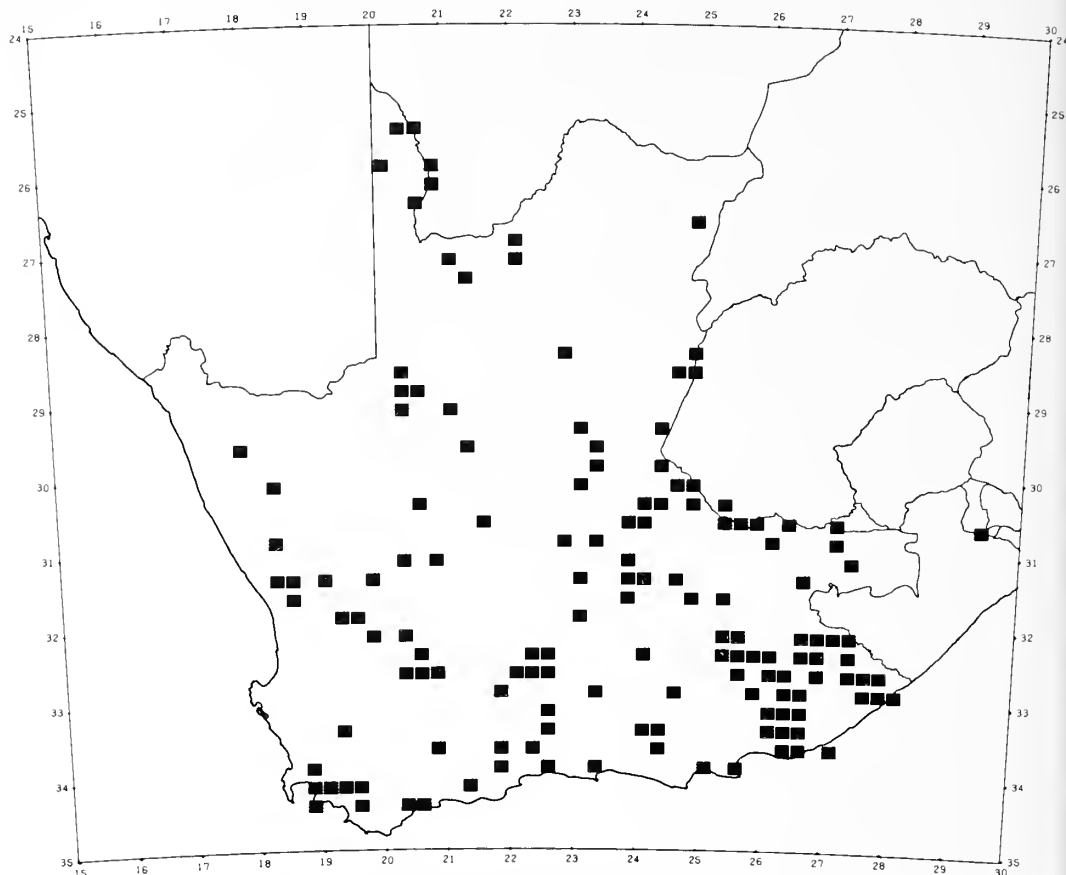


Fig. 11. The distribution of the Martial Eagle according to published and unpublished records (ex CDNEC 1976 Postal Survey data) between 1970 and 1979.

### *Abundance*

The Martial Eagle is represented in the Cape Province by an estimated 52 pairs. This is an average of less than one pair per degree square. The range of the estimate is between 17 and 116 pairs (Table 2) and therefore even at the upper estimate there is less than one pair of Martial Eagles per 5 000 sq. km. If a pair of Martial Eagles has a home range of 400 sq. km., which is double the estimate for birds in the Kruger National Park (Snelling 1969), there must be considerable areas of the Cape where there are no resident pairs. It is not possible to provide a comparative estimate of the abundance of the Martial Eagle in the Cape Province. There were 30 eyries tabulated by the ground-truth survey.

The density of Martial Eagles is greatest in the E. Cape and even within that region they are localised. The 1976 Survey indicates that the degree squares 32 26 and 32 27 contain a greater density than other squares; this is the area between Bedford and Komga. The ground-truth survey also found the species to be most numerous in that area.



The Abundance of the Black, Crowned and Martial Eagles, estimated from the 1976 Survey, can be compared with estimates from the ground-truth survey for the E. Cape south of 32° S. The totals for all three species for seven degree squares are given in Table 3. It is concluded that, for this zone at least, the 1976 Survey provided a reasonable estimate of the numbers of breeding pairs of these three eagles.

TABLE 3

*Estimates of the numbers of breeding pairs of three species of eagle in part of the Eastern Cape, based on the results of the CDNEC 1976 Survey and the ground-truth survey*

Degree Square	Black Eagle		Crowned Eagle		Martial Eagle		Total	
	1976*	G-T**	1976	G-T	1976	G-T	1976	G-T
32 25	27	12	1	2	3	4	31	18
32 26	19	17	5	13	8	6	32	36
32 27	12	7	3	8	6	6	21	21
32 28	0	2	0	4	0	1	0	7
33 25	10	7	1	2	3	4	14	13
33 26	7	4	5	17	3	4	15	26
33 27	1	0	0	1	0	0	1	1

\*1976 Survey.

\*\*Ground-truth survey.

### Fish Eagle

#### *Distribution*

The 1976 Survey indicated that the Fish Eagle is found along the coast and along the Orange River and that it avoids the arid western part of the Cape Province (Fig. 12). The breeding distribution of the Fish Eagle is even more restricted (Fig. 13). The results of the 1976 Survey are similar to the distribution pattern obtained from other sources (Fig. 14).

The Fish Eagle was the species most frequently correctly identified by the farmers. Accordingly the authors consider that many of the reports of the presence of the Fish Eagle are valid. Thus Fig. 12 is interpreted to mean that the species wanders widely from its permanent breeding grounds to areas offering a suitable though temporary habitat.

#### *Abundance*

There are an estimated 56 pairs of Fish Eagles in the Cape. The confidence limits of this estimate range between 12 and 146 pairs (Table 2). A comparable estimate of 45 pairs was made by the ground-truth survey through tabulation of known eyries and extrapolation to areas not covered by the ground-truth survey.

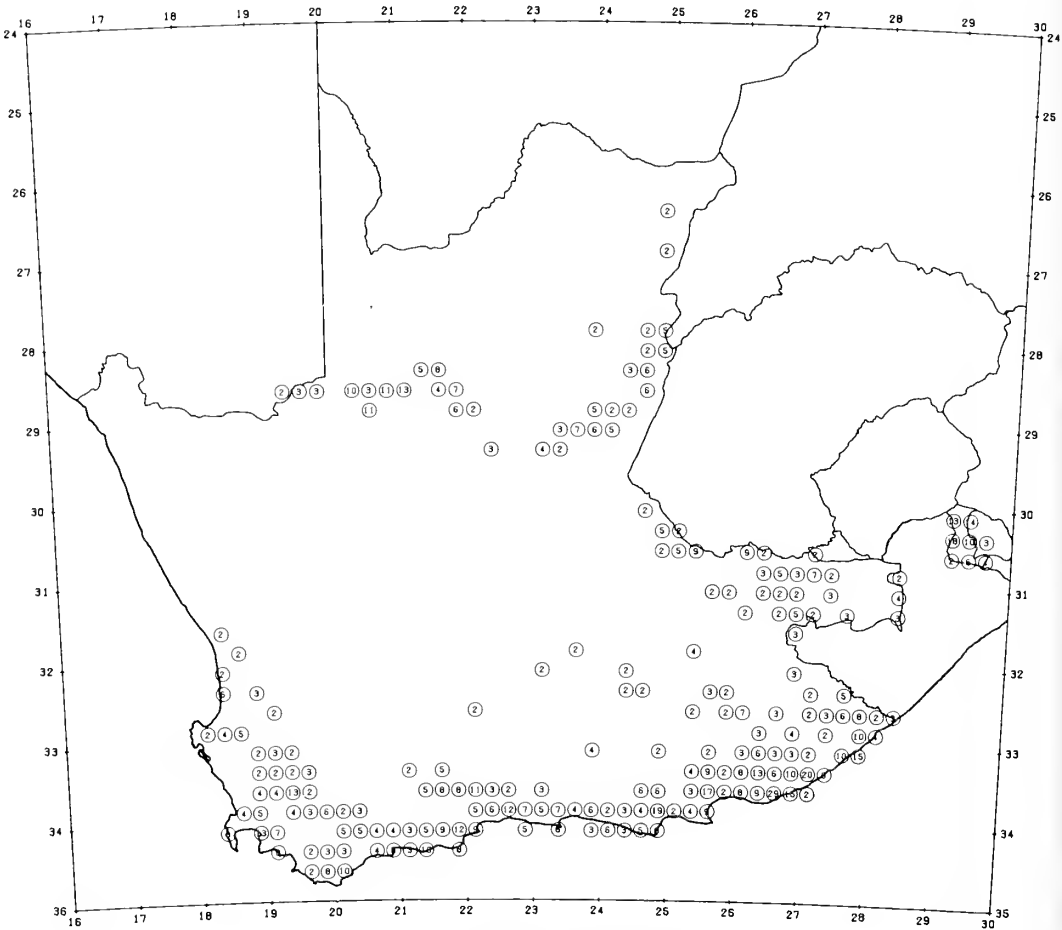


Fig. 12. The distribution of farmers reporting the presence of Fish Eagles on their farms in the CDNEC 1976 Survey. Circled digits represent totals per locus.

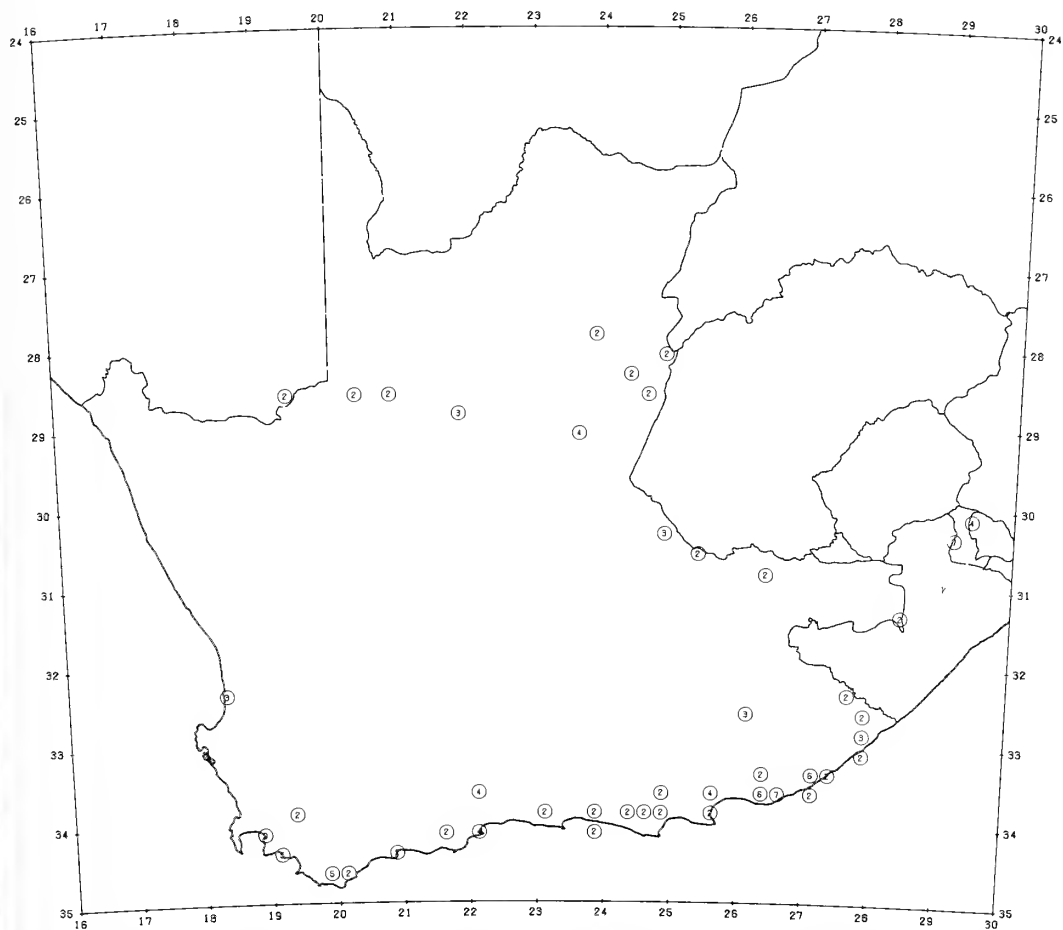


Fig. 13. The distribution of farmers reporting breeding by Fish Eagles on their farms in the CDNEC 1976 Survey. Circled digits represent totals per locus.

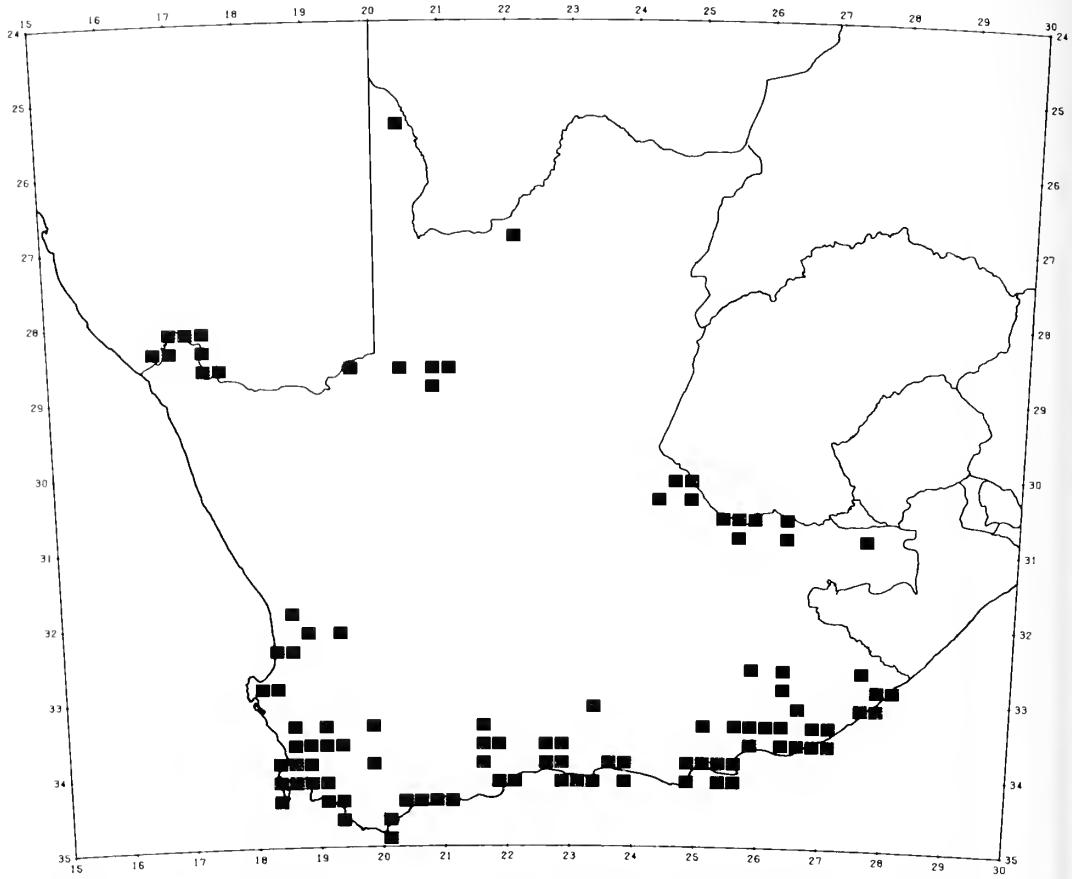


Fig. 14. The distribution of the Fish Eagle according to published and unpublished records (ex CDNEC 1976 Postal Survey data) between 1970 and 1979.

### Tawny Eagle

#### Distribution

The reports of the presence of the Tawny Eagle in the Cape Province are mapped in Fig. 15. This map has little reliability because of the high frequency with which the Tawny Eagle was misidentified (Table 1). The map of the breeding distribution of the Tawny Eagle (Fig. 16) shows that it occurs mainly in the N. Cape. Most, if not all of the few reports from the E. Cape are considered to be misidentifications. The distribution data obtained from other sources (Fig. 17) confirm the pattern of distribution seen in Fig. 16. The concentration of records from the Colesberg-Venterstad districts (portions of degree squares 30 24 and 30 25) is due to the

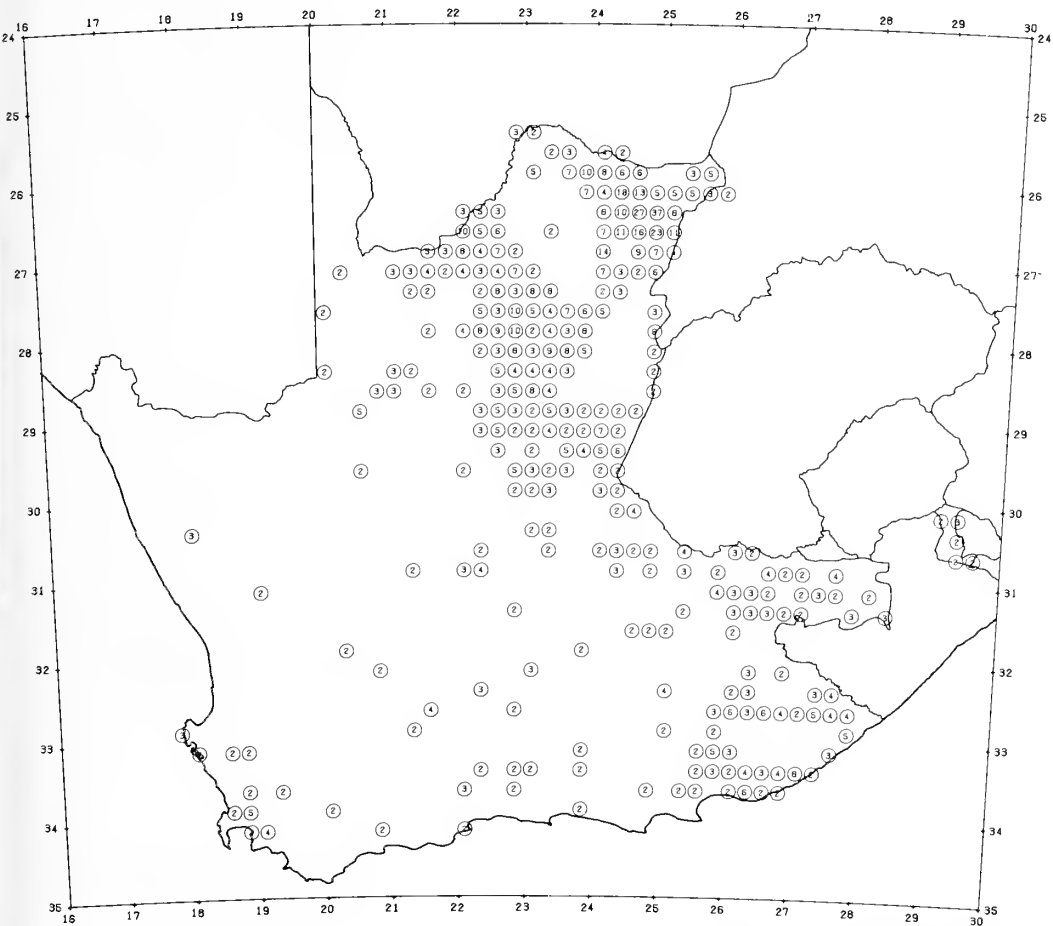


Fig. 15. The distribution of farmers reporting the presence of Tawny Eagles on their farms in the CDNEC 1976 Survey. Circled digits represent totals per locus.

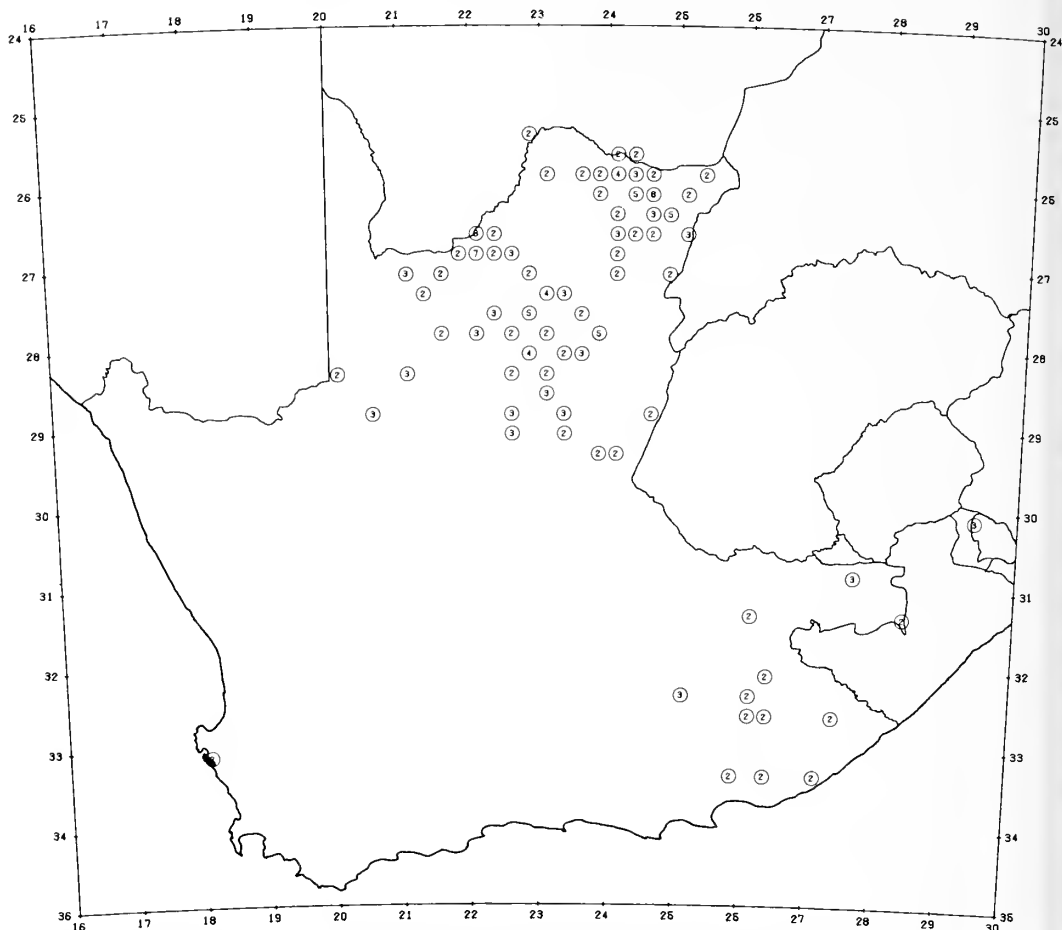


Fig. 16. The distribution of farmers reporting breeding by Tawny Eagles on their farms in the CDNEC 1976 Survey. Circled digits represent totals per locus.

concerted efforts of R. C. Rous to locate eagle nests in these areas. Within this limited zone there are six breeding records for the past three years. Consequently it is possible that this species occurs more frequently in the northern parts of the E. Cape and the north-western Karoo than was thought. During the past nine years there have been a further six sight records from the E. Cape.

#### *Abundance*

No estimate could be made from the 1976 Survey. All the correct identifications of this eagle came from the N. Cape and the Tawny Eagle may be as numerous there as the Black Eagle or the Martial Eagle.

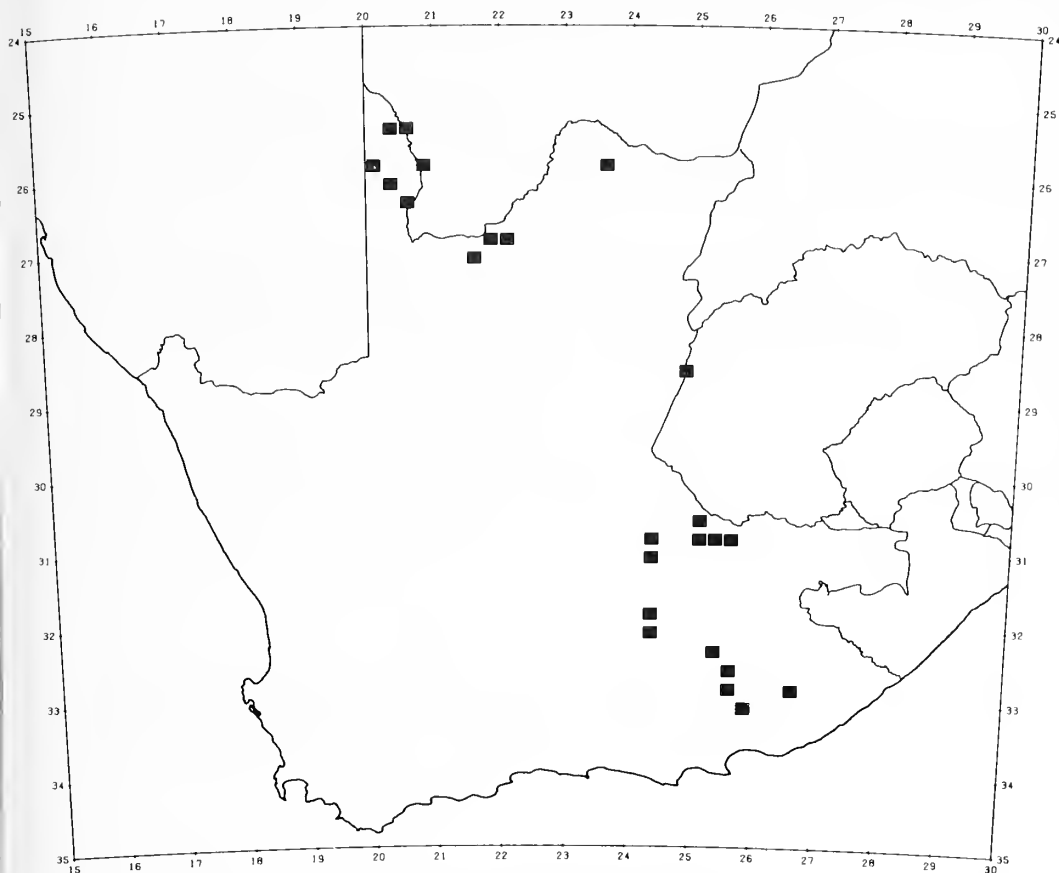


Fig. 17. The distribution of the Tawny Eagle according to published and unpublished records (ex CDNEC 1976 Postal Survey data) between 1970 and 1979.

### Bateleur

The confusion of this eagle with other species in the 1976 Survey prevents any reasonable conclusions from being made about the distribution and abundance of the Bateleur. The six correct identifications confirmed by the ground-truth survey were all made by farmers in the N. Cape. This was also the only region where Bateleurs were seen by the ground-truth survey. There are a few isolated sight records of the Bateleur from the Karoo and E. Cape, made during the 1970s by other observers. The findings of the 1976 Survey are restricted to the statement that the Bateleur may still breed in the N. Cape but elsewhere in the Cape it is absent or a rare vagrant.

### Long-Crested Eagle

Little of value was detected by the 1976 Survey about the distribution and abundance of the Long-crested Eagle. The breeding records (not illustrated) are confined to four, two from the

E. Cape and two from the S.W. Cape. The Long-crested Eagle was not observed by the ground-truth survey and very few sight records were made during the 1970s. The paucity of information resulting from the 1976 Survey is a valid indication of the rarity of this species in the Cape Province.

### Black-Breasted Snake Eagle and Bearded Vulture

The 1976 Survey did not reveal any worthwhile information about these two species. Both species are rare in the Cape Province and most, if not all, reports by the farmers were based upon misidentifications. The present distribution of the Bearded Vulture is confined to the north-eastern Cape (Boshoff *et al.* 1978).

### DISCUSSION

The 1976 Survey yielded a valid picture of the status of eagles in the Cape Province. It showed that there are only four species which are present in any numbers. These are the Black Eagle, Crowned Eagle, Martial Eagle and Fish Eagle. The inclusion of the Fish Eagle negates the possibility that the farmers were only reporting the species that affected their stock. As the farmers have a favourable attitude towards the Fish Eagle they were also reporting in general about the eagles of which they were aware.

This suggests that the remaining species of eagles that occur in the province are scarce, unobtrusive or localised. The Tawny Eagle and Long-crested Eagle represent localised species, the Booted Eagle *Hieraaetus pennatus* is unobtrusive and the Bateleur, Black-breasted Snake Eagle and Long-crested Eagle are rare. The Booted Eagle was not included in the questionnaire, and the ground-truth survey indicated that the farmers were unaware of its presence or identity. This is surprising as farmers in general were aware of the small raptors, which were not included in the questionnaire, such as the Jackal Buzzard, Black-shouldered Kite *Elanus caeruleus* and Lanner Falcon *Falco biarmicus*.

It is unlikely that the same knowledge of the status of eagles in the entire province could have been obtained in any other way for the same expenditure of time, manpower and finance. A hidden advantage of the survey was that all farmers were reached and that contact was made with many genuinely interested in eagles and conservation. Over such a vast area it might otherwise have been difficult to reach these potential opinion leaders.

The survey presents a picture of the status of eagles in the Cape Province in the 1970s. It is a static sample and does not reveal any trends. Thus no conclusions can be made as to whether the eagles are increasing or decreasing in numbers, or holding their own. Temporal trends could only be established if the survey were to be repeated sometime in the future. As farmers' reports of raptors were often drawn from their lifetimes' experiences, it will be necessary to re-phrase the questionnaires before repeating the survey.

Although the 1976 Survey does not show trends in the status of eagles, deductions can be made if the information is considered in conjunction with all past and present records of eagles (Boshoff *et al.* in prep.) and an evaluation of the relationship between stock farmers and eagles (Boshoff & Vernon in prep.).

The authors consider that the Black Eagle and the Crowned Eagle still have viable populations. Though persecuted, several factors allow them to persist. The nature of their habitats, mountains and forests respectively, make these eagles relatively inaccessible. Their natural prey, dassies and monkeys, are still relatively numerous permitting pairs of breeding eagles to survive without encroaching on domestic stock. Birds that take stock tend to be juveniles which have dispersed from their natal areas and consequently the number of these eagles removed by farmers appears to be less than the breeding increment. There is no reason why such a situation cannot persist indefinitely.



Little comment can be made about the status and conservation of the Fish Eagle in the Cape Province. There is no indication that farming has affected the population of this species in any adverse way. The species may, however, be declining due to human disturbance (Siegfried *et al.* 1976). The main causes of the decline are probably pollution and urban development around estuaries. However, the many artificial water impoundments created in recent times appear to have benefited the population by the provision of additional permanent food sources as well as breeding sites such as partially drowned trees.

The Martial Eagle population may be in jeopardy and certainly gives cause for concern. The species is rightly listed as vulnerable in the *South African Red Data Book—Aves* (Siegfried *et al.* 1976). The population is small and widely dispersed. Even if there were 100 pairs, each with a territory of 10 km. radius, there would be no Martial Eagles breeding in nine-tenths of the Cape Province. The species is not liked by farmers in general, even those who are favourably disposed towards other eagles. It is testimony to the resilience of the Martial Eagle that it still exists in the province. As with the Fish Eagle the Martial Eagle has capitalized to a large extent on man's activities in that it readily nests on power pylons (Dean 1975b; A. Daneel *pers. comm.*; *pers. rec.*) and in exotic trees, such as pines, eucalypts and poplars, often introduced to farms (R. Martin *pers. comm.*; *pers. rec.*). In the Karoo, where suitable nest trees are scarce, two nests of this species on cliffs are known (M. H. Currie, *pers. comm.*). Similarly the Tawny Eagle is also known to nest in exotic trees in the Colesberg district (R. C. Rous *pers. comm.*).

As biologists the authors wonder how a species such as the Martial Eagle, which occurs at low density and under such pressure, is able to persist. As conservationists they are alarmed at the level of persecution. Other than the Kalahari Gemsbok National Park, there are no large reserves in the Cape Province, where a viable population of these eagles might persist. Consequently the responsibility for the conservation of eagles in the province depends upon the farmers. There appear to be several socio-economic factors associated with eagles and the stock problem which need further elucidation (Boshoff & Vernon in prep.).

### CONCLUSION

Useful and valid information was obtained about the distribution and abundance of four species of eagles in the Cape Province. The findings are applicable to the entire province. Despite certain disadvantages, the method employed seems to be the only way of obtaining such complete coverage. Although the results do not reveal trends, certain deductions can be made if these data are linked with ancillary information. There are nine species of eagles known to breed in the province and five—Black Eagle, Tawny Eagle, Crowned Eagle, Fish Eagle and Booted Eagle—appear to have viable, if small, populations. A sixth species, the Martial Eagle may be declining to extirpation. The 1976 Survey was valuable in that it presented a broad review of the status of eagles and gave pointers for more intensive investigations.

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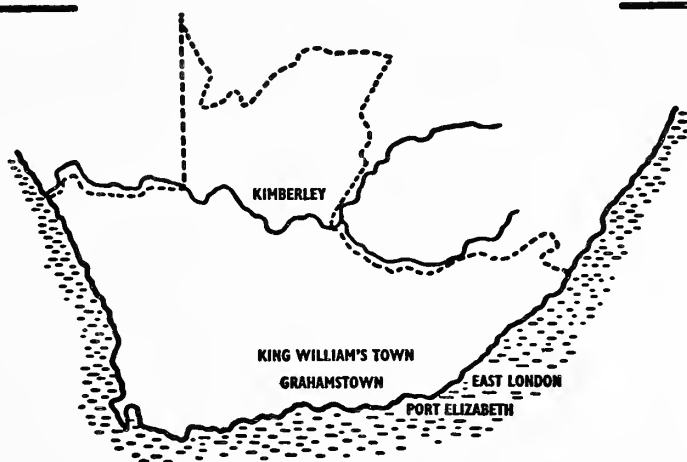
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# Early names and records of two small *Hieraaetus* eagles (Aves: Accipitridae) in the Cape Province of South Africa

by

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## ABSTRACT

Names and records of Ayres's Hawkeagle and the Booted Eagle, chiefly in the Cape Province of South Africa are discussed. *Morphinus dubius* Smith was said by Roberts to be the first name applied to Ayres's Hawkeagle and as a result the species is universally called either *Hieraaetus dubius* or *Aquila dubia*. Smith's type may not have survived but his description lacks reference to any character diagnostic of Ayres's Hawkeagle whereas it is a straightforward description of a pale phase Booted Eagle *H. pennatus*. Thus *M. dubius* is a junior synonym of *H. pennatus* and the first available name for Ayres's Hawkeagle is *Spizaetus ayresii* Gurney. The type locality of *M. dubius* is in the Vredendal District of the western Cape hundreds of kilometres from the woodlands and forests which *H. ayresii* frequents. There is no satisfactory evidence for the occurrence of *H. ayresii* in the western Cape and all records are rejected. In the eastern Cape some records are acceptable but all are of wandering immature birds. The most southerly record of an adult is from the northern Transkei. Most misidentifications are of *H. pennatus* which is now known to be relatively common in the Cape Province. A Zambezi valley record of *H. ayresii* is validated.

## WHAT IS MORPHINUS DUBIUS?

The name *Morphinus dubius* Smith (1830a) (full citations of names will be found in Appendix 1) lay unused for over 100 years because it was believed to be indeterminate. Roberts (1936: 321) argued that *M. dubius* was the first description of Ayres's Hawkeagle *Spizaetus ayresii* Gurney (1862). There has been no further discussion of Roberts's view but it has been universally accepted and for over 40 years Ayres's Hawkeagle has been referred to as *Hieraaetus dubius* or *Aquila dubia* according to taxonomic taste.

Smith (1830a) used the generic name *Morphinus* and attributed it (p. 115) to Cuvier. In Smith (1834) he corrected the name to *Morphnus* (p. 276) still attributing it to Cuvier. As Friedmann (1950: 421) makes clear, *Morphinus* is an unjustified emendation by Fleming in 1822 of Dumont's, 1816, *Morphnus* which Dumont attributed to Cuvier, presumably in MS.

In the course of C.J.V.'s investigations into the past and present distribution of eagles in the Cape Province it has emerged that Ayres's Hawkeagle is a rare vagrant and that several of the claimed records are unacceptable. A critical reading of Smith (1830a) does not permit agreement with Roberts's (1936) findings on *M. dubius*. There are no characters in the description which apply it unequivocally to Ayres's Hawkeagle: it lacks any reference to an occipital crest, an evenly barred tail or ginger coloured underparts, the three plumage characters that separate juvenile Ayres's Hawkeagle from the similarly sized Booted Eagle *H. pennatus* (Gmelin) 1788.

Smith's (1830a) text is a good description of a pale phase *H. pennatus* "plumage above . . . the shafts of the feathers and a portion of the vanes adjoining being always darkest; . . . chin, throat, and centre of breast chiefly white, with some brown shades in the form of longitudinal streaks that include the shafts of the feathers; belly white, here and there variegated with clouds of light reddish-brown or with dark brown narrow streaks, produced by the shafts being that colour. Several of the long feathers on the flanks more or less distinctly crossed with reddish-brown, and those on the outside of the thighs also slightly marked in the same way, only with a lighter shade, the rest of the feathers of the legs pure white . . . insides of shoulders *white*, with a few blackish-brown spots or blotches. Tail nearly *even*, the feathers blackish-brown, variegated with *narrow waved irregular bands* of a darker tint," (italics added).

The type of *M. dubius* may not have survived and this is true of several of the types of animals described by Andrew Smith while still in South Africa. However, Smith (1834) synonymized his *M. dubius* with his newly proposed *Butaetes lessonii* of which the type survives in the British Museum (Natural History) under reg. no. 43.2.28.64. The register, but not the label, states that the specimen is *Buteo (sic) lessonii* and the entry lies among a batch of Andrew Smith's types registered at the same time (C. W. Benson in litt. 1978 to R.K.B.). The specimen is, as the description would lead one to expect and did lead Hartert (1914) to find, an undoubted pale phase *H. pennatus*. This view of what is meant by *M. dubius* is supported by Smith's (1834) revision coupled with the identity of the surviving second type.

The view taken of the relationship between *M. dubius* and *B. lessonii* in the preceding paragraph is not the only possible one in the light of known taxonomic practice in the early XIX century. It is quite possible, indeed very likely, that Smith regarded *B. lessonii* as a redescription of *M. dubius* in a more appropriate genus and with a less inappropriate specific epithet. This is borne out by the fact that the description of *B. lessonii* is a shortened version of that of *M. dubius* and does not differ from it positively in any respect. If this suggestion is truly the case, then specimen no. BM(NH) 43.2.28.64 is the type not only of *B. lessonii* as argued above but also of *M. dubius*. This suggestion could be disproved by critically comparing the specimen with the description of *M. dubius*.

#### CONSEQUENCES OF FINDING

What follows from this finding? In the first place, as set out in Appendix 1, the name *dubius* of Smith cannot be applied to Ayres's Hawkeagle and workers must revert to calling the species *ayresii* of Gurney in whatever generic combination seems warranted: preferably *Hieraetus ayresii*, cf. Brooke (1974). Smith's *M. dubius* must be placed in and *Butaetes lessonii* must be restored to the synonymy of *H. pennatus* (Gmelin) as Hartert (1914) held and contra Brooke (1974). If the South African breeding population of *H. pennatus* proves taxonomically separable from west Palaearctic breeding populations (this does not seem likely to be the case), *M. dubius* is the first name applied to South African birds and would form their subspecific epithet. Heerenlogement, the type locality of *M. dubius*, must be restored to the list of localities in the Cape Province at which *H. pennatus* has been collected since its rejection by Brooke (1974) has been shown to be unwarranted. Likewise, the sight and breeding records at Franschoek and east of Klaver made in 1917 by Roberts (1936: 322) attributed to

*H. ayresii* must be transferred to *H. pennatus* which is now known to be a widespread breeding species in the Cape Province south of the Orange River (Brooke *et al.* 1980).

#### OTHER RECORDS REVIEWED

*Morphinus albescens* Smith (1830a) was transferred by Brooke (1974) to the synonymy of *Spizaetus coronatus* (L.), 1766, from that of *H. pennatus* where Hartert (1914) had provisionally placed it. In his 1834 revision Smith admitted *S. coronatus sub nom. Aquila coronata* to the South African avifauna (p. 273) but did not realise that his *M. albescens* was only its juvenile. Roberts (1936: 294) seems to have made a reciprocal error in dealing with Smith's MS entry under *M. ornatus*. Roberts did not publish the lengthy descriptions that Smith wrote so it is not practicable to check what Smith was describing: one may accept Roberts's view that they apply to *S. coronatus*. Nonetheless, the notes that Roberts (1936) did publish, including the reference to a specimen shot at the Heerenlogementsberg in January 1829, only make sense when applied to *H. pennatus*. Smith's bird had a "Bill towards cere bluish . . . cere and feet a sort of greenish yellow" whereas *S. coronatus* has a black bill with dark cere. The habitat is an arid scrubcovered mountain rising out of a semidesert plain which is appropriate for *H. pennatus* (Brooke *et al.* 1980) but not for *H. ayresii* and *S. coronatus* which are eagles of forest and woodland. And Smith (Roberts 1936) said his species was "very common".

Roberts (1936: 322) mentions a specimen of *H. ayresii* which he examined in the South African Museum, Cape Town. R.K.B. has recently re-examined it and it is an undoubted *H. ayresii* as Roberts said. It is a small adult male with hardly any markings on the underparts. The label, written in the last century, says "Cape District—purchased" and there is no information given on who collected it or sold it to the museum. The unsatisfactory wording of the label is not proof that *H. ayresii* has occurred in the western Cape (west of 25°E and south of 29°S) in recorded history in the absence of any other records which might be called analogously in its support.

In addition to the adult male specimen of uncertain provenance just discussed there are three or four specimen records of *H. ayresii* from the eastern Cape which are acceptable. The earliest was collected c. 1820 by Mundt and Le Maire, two Prussian botanists (ffolliott & Liversidge 1971), somewhere on the Sundays River: it is a juvenile female in the Humboldt Museum, Berlin (Stresemann 1924). There is an unsexed juvenile from Grahamstown taken in 1910 in the Albany Museum, Grahamstown, which is also mentioned by Finch-Davies (1919) and another unsexed juvenile without date in the East London Museum merely labelled "eastern Cape Province". The label, at least, must have been written in or after 1910 when the Cape Colony became the Cape Province. This is probably not the juvenile female from near Port Elizabeth mentioned by Finch-Davies (1919).

Layard (1867) placed the Buse Gantée of Levaillant (1796) in the synonymy of *H. pennatus*. This is clearly incorrect. Smith (1830b) pointed out that European workers had placed it as a synonym of the Roughlegged Buzzard *Buteo lagopus* (Pontoppidan, 1763, *Danske Atlas* p. 616: Denmark) which is clearly the species of the picture and much of the description. But the species does not occur in the Cape Province: the most southerly recorded localities in Vaurie (1965) are Cyprus and Malta. What was the specific identity of the Outeniqua forests specimen, shot by Levaillant, which was so like *B. lagopus* that he failed to distinguish it? After discussion between R.K.B. and Dr L. H. Brown it seems nearly certain that the specimen was a subadult *H. ayresii*. Living solitarily in forested country is appropriate and so are the heavily blotched tarsal feathers reaching to the toes with their long thin, "plus effilées", claws. R. Martin (pers. comm. to R.K.B.) who has a good knowledge of the forested country of George and Knysna, the Outeniqua forests of early writers, has never seen *H. pennatus* there despite search. And it would seem less easy to muddle the European *H. pennatus* with *B. lagopus* than

the then unknown *H. ayresii* in immature plumage. Thus Levaillant's Buse Gantée is almost certainly the first record of a vagrant immature *H. ayresii* in the eastern Cape.

Skead (1967) gives three other records of *H. ayresii* from the eastern Cape. Those from Golden Valley and King Williams Town in 1966 have been re-examined and they prove to be specimens of *H. pennatus*. The 1962 record from King Williams Town is a MS sight record by G. Ranger and C. J. Skead at Kei Road on 7 April 1962 of a juvenile *H. ayresii* described as having an "unmistakable crest". This record seems acceptable, not least because of the lengthy field experience of both observers. It will be noted that all indubitable records from the Cape Province (not the extralimital Transkei) are of juvenile or immature birds. The only adults are the South African Museum specimen whose provenance is uncertain and one which was shot in Pondoland, Transkei, in February 1909 but which was not preserved (Finch-Davies 1919).

*H. ayresii* was recorded by Winterbottom (1971: 60) from Goodhouse on the Orange River where it forms the frontier between the Cape Province and Namibia but the source of this record is not known (Dr J. M. Winterbottom pers. comm. to R.K.B.). In the absence of supporting details this record of a forest and woodland eagle in the desert is unacceptable and *H. ayresii* should not be admitted to the Namibian list on the strength of this record.

Sclater (1905) and Stoehr & Sclater (1906: 109) recorded the collection of *H. spilogaster* on 25 February 1904 from George's Ferry at 15° 40'S, 30° 18'E on the Zambian bank of the Zambezi (Benson *et al.* 1970: 55) a few kilometres upstream from Feira at the junction of the Luangwa and Zambezi Rivers. Finch-Davies (1919) redetermined this specimen as *H. ayresii* and even provided a coloured portrait of it to illustrate his paper. This redetermination was overlooked by Benson *et al.* (1971) who stated that *H. ayresii* had not yet been recorded in the Zambezi and Luangwa valleys. The specimen has been demounted but is still preserved in the South African Museum where R.K.B. has recently examined it and found it to be, as Finch-Davies (1919) said, an adult female *H. ayresii*.

As a result of the foregoing findings Map 101 for *H. ayresii* in Snow (1978) needs to be amended by the deletion of the four symbols in the western Cape and by the addition of one at the Luangwa/Zambezi confluence.

Brooke (1974) was written before he had seen the South African Museum material of *H. pennatus*. Table 1 may be regarded as a continuation of Table 1 in Brooke (1974) in that it provides analogous data on the South African Museum specimens. The Wynberg specimen which was formerly mounted was collected by Dr H. Exton, cf. Winterbottom (1955).

TABLE 1

*Data on specimens of Hieraaetus pennatus pennatus examined in the South African Museum, Cape Town. All measurements in mm.*

Date	Place	Sex	Age	Wing length	Culmen length	Hind Claw length	Phase
c. 1870	Wynberg, C.P.	♂	ad.	350	19,8	20,7	dark
c. 1880	—	♂	ad.	355	21,5	22,5	pale
c. 1900	—	♀	imm.	385	22,3	26,2	pale
4.10.1910	Robertson, C.P.	♀	imm.	370	21+	26,2	pale
24.11.1910	Lynedoch, C.P.	♂	ad.	360	20,5	22,0	pale



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APPENDIX 1

Citations and type localities of names accepted as valid or synonymous in this paper. The synonymies for *H. pennatus* and *H. ayresii* are believed to be complete.

\*Indicates original reference examined by R.K.B.

*HIERAAETUS* Kaup

*Hieraaetus* Kaup, 1844, *Class. Saeug. Voegel* p. 120. Genotype *Falco pennatus* Gmelin by original designation.

Synonyms

*Eutohnaetus* Blyth, 1845, *J. Asiat. Soc. Beng.* **14**: 174. Genotype *Aquila fasciata* Vieillot by original designation.

\**Anomalaetus* Roberts, 1922, *Ann Transv. Mus.* **8**: 208. Genotype *Spizaetus ayresii* Gurney by original designation and monotypy.

*HIERAAETUS PENNATUS* (Gmelin)

\**Falco pennatus* Gmelin, 1788, *Syst. Nat.* **1** (1): 272, no locality but restricted to France by Swann, 1922, *Synopsis Accipitres* p. 113.

*HIERAAETUS PENNATUS PENNATUS* (Gmelin)

Synonyms

*Aquila minuta* Brehm, 1820, *Beitr. Vogelkd.* **1**: 68, Orla River, western Poland.

\**Morphinus dubius* Smith, 1830, *S. Afr. Q. Jl.* **1** (2): 177, Heerenlogement at 31° 58'S, 18° 34'E in the Vredendal District, western Cape Province, South Africa.

\**Butaetes lessonii* Smith, 1834, *S. Afr. Q. Jl.* (2) **3** (3): 287, Heerenlogement.

*Aquila brehmii* von Mueller, 1851, *Naumannia* **1** (4): 24, Melpes, Kordofan Province, Sudan.

*Aquila nudipes* von Mueller, 1851, *Naumannia* **1** (4): 25, South Africa.

*Aquila paradoxa* Brehm, 1853, *J. Orn., Lpz.* **1**: 204, northeastern Africa at 15°N.

*Aquila longicaudata* Heuglin, 1855, *Sber. Akad. Wiss. Wien* **19**: 258, Shereik, Northern Province, Sudan.

*Aquila gymnopus* Heuglin, 1855, *Sber. Akad. Wiss. Wien* **19**: 258, *nom. nov. pro A. nudipes* von Mueller.

*Aquila maculatirostris* Brehm, 1856, *Allg. dt. naturh. Ztg.* p. 46, Sudan.

*Aquila pygmaea* A. E. Brehm & C. L. Brehm, 1861, *Ber. dt. Orn. Ges.* p. 99, Madrid, Spain.

*Hieraetos (sic) pennatus major & medius* A. E. Brehm, 1866, *Verz. Samml.* p. 2 are *nom. nud.*

*Aquila albipectus* Severtsov, 1873, *Turkest. Zhivotn.* p. 63, Alma Ata, Kazakh S.S.R., U.S.S.R.

*HIERAAETUS PENNATUS MILVOIDES* (Jerdon)

*Spizaetus milvoides* Jerdon, 1839, *Madras J. Lit. Sci.* **10**: 75, Tiruchchirappalli, Madras Province, India.

Synonym

*Hieraaetus pennatus harterti* Stegmann, 1935, *Orn. Mber.* **43**: 151, Kyakhta, southwestern Transbaicalia, U.S.S.R.

*HIERAAETUS AYRESII* (Gurney)

\**Spizaetus ayresii* Gurney, 1862, *Ibis* **4**: 149 and pl. 4, near the coast of Natal.

Synonyms

\*Buse Gantée Levaillant, 1796, *Histoire naturelle des oiseaux d'Afrique* **1**: 79 and pl. 18, Outeniqua, Cape Province, South Africa (*partim*).

*Lophotriorchis lucani* Sharpe & Bouvier, 1877, *Bull. Soc. zool. Fr.* p. 471, Landana, Cabinda, Angola.

EARLY NAMES AND RECORDS OF TWO SMALL HIERAAETUS EAGLES

*HIERAAETUS SPILOGASTER* (Bonaparte)

*Aquila spilogaster* Bonaparte, 1850, *Rev. Mag. Zool.* p. 487, Ethiopia.

*SPIZAETUS* Vieillot

\**Spizaetus* Vieillot, 1816, *Anal. Nouv. Orn. Elem.* p. 24. Genotype *Falco ornatus* Daudin by subsequent designation by Gray, 1840, *List Gen. Birds* p. 2.

Synonym

\**Stephanoaetus* W. L. Sclater, 1922, *Bull. Br. Orn. Club* 42: 75. Genotype by original designation and monotypy *Falco coronatus* Linnaeus.

*SPIZAETUS CORONATUS* (Linnaeus)

*Falco coronatus* Linnaeus, 1766, *Systema Naturae*, ed. 12, vol. 1: 124, Guinea coast of west Africa.

Synonyms

*Falco albescens* Daudin, 1800, *Traité Orn.* 2: 45, Outeniqua, Cape Province, South Africa.

\**Morphinus albescens* Smith, 1830, *S. Afr. Q. Jl.* 1 (2): 155, Outeniqua, Cape Province, South Africa.





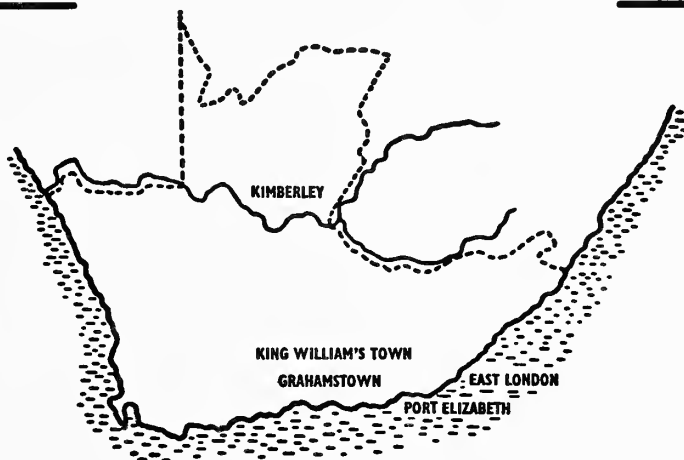


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# ANNALS OF THE CAPE PROVINCIAL MUSEUMS

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# **An annotated checklist of the lizards of the Cape Province, South Africa**

by

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## **ABSTRACT**

A checklist of the lizards of the Cape Province, South Africa is presented. A total of 143 species and subspecies is recognized. The taxonomic status of no less than 84 (59,1%) of these has changed since the last review of the Cape lizards by FitzSimons (1943). Comments on the distribution and taxonomic status of problematic groups are included.

## **INTRODUCTION**

Recent years have seen a burgeoning interest in the small vertebrate fauna of the Cape Province. This is coupled with the awareness of the uniqueness and zoogeographic importance of the Fynbos Biome and adjacent regions (Kruger, 1978). Studies on the herpetofauna of the Fynbos Biome are minimal, and hampered by poor taxonomy. This is particularly acute for

lizards, which present the greatest diversity among the reptiles. The suborder was last reviewed by Dr V. F. M. FitzSimons (1943) in his monograph on the "Lizards of South Africa." However, during the intervening 37 years numerous taxonomic changes at the familial, generic and specific level have occurred.

This review originated as a checklist of the lizards inhabiting the Fynbos Biome, incorporating all the diverse taxonomic changes that have occurred subsequent to FitzSimons' monograph (1943). However, accurate distribution maps exist for very few lizards inhabiting the Cape Province and this makes it impossible to identify all those species that may inhabit the Fynbos Biome. The scope of the review has thus been expanded to cover the total lizard fauna of the Province. The eastern border of the Cape Province remains in a state of political flux. As currently recognized, it consists of a wavy line running from East London to Lesotho. The only lizard affected by this is *Afroedura pondolia*, that reaches its western limit at Kentani (3228 AD) and thus no longer qualifies for Cape residence.

The taxonomy of a number of genera and species is now relatively well stabilized, but that of many remains confused. Some of these problem groups are currently under investigation, and the results of these studies will in due course affect this review. In addition the distributions of most species are only poorly known and will alter as the region becomes better collected. Subject to these limitations, 143 species and subspecies of lizards are known to occur in the Cape Province (Table 1). No less than 84 (59.1%) of these have been affected by some form of taxonomic change since FitzSimons' monograph (1943). However, only one new species and three new subspecies of lizard have been described from the Cape in this time, and it is evident that the alpha-phase of the taxonomy of South African lizards, in which new species are discovered, has all but passed. Future studies will, for the most part, refine our knowledge of the relationships of the known forms, and few new species can be expected.

CLASS: REPTILIA  
ORDER: SQUAMATA  
SUBORDER: SAURIA

There is still discussion concerning the ordinal classification of squamate reptiles. The extensive studies of Gans (see review 1978) have convincingly demonstrated that burrowing "worm lizards" differ from true lizards in many characteristics, and should be elevated to equivalent rank within the Squamata. The suborder Amphisbaenia is represented in southern Africa by only four genera; *Monopeltis*, *Dalophia*, *Chirindia* and *Zygaspis*. The species *Monopeltis capensis capensis*, *M. leonhardi*, *M. sphenorhynchus mauricei*, *Dalophia pistillum*, and *Zygaspis quadrifrons* all range into the northern Cape Province in the vicinity of the Kalahari Gemsbok National Park and Kimberley. The taxonomy of all these forms has recently been reviewed (Broadley, *et al.*, 1976; Saiff, 1970) but refinements can still be expected. Chromosome morphology indicates that *Monopeltis capensis rhodesianus*, at least, warrants specific recognition (Branch, unpublished observations).

The osteological studies of McDowell and Bogert (1954) indicate that the Gerrhosauridae and Cordylidae are closely related, and best treated as subfamilies of the Cordylidae. The suborder Sauria is thus represented in southern Africa by only seven families out of the 17 families of Recent lizards currently recognized (Dowling and Duellman, 1978).

INFRAORDER: GEKKOTA

The Infraorder Gekkota contains two living families, Gekkonidae and Pygopodidae. The pygopodids are derived from geckos through elongation of the body and loss of limbs, and are restricted to the New Guinea—Australian region.

## CHECKLIST OF CAPE LIZARDS

### Family: Gekkonidae

An ancient and widespread family. Underwood (1954) proposed a division of gekkonid lizards into three families, based mainly on the shape of the pupil. Within the Gekkonidae, he placed the southern African genera *Chondrodactylus*, *Colopus*, *Palmatogeko*, *Ptenopus*, *Rhotropella* and *Rhotropus* into the subfamily Diplodactylinae, whilst all remaining South African geckos remained in the Gekkoninae. Kluge (1967) demonstrated that divisions based on pupil shape were unnatural and recognized only a single family with four subfamilies. He referred all South African geckos to the Gekkoninae, the Diplodactylinae being restricted to the Australian subregion. Haacke (1975, 1976a, 1976b, 1976c, 1976d) in a detailed study of the burrowing geckos of southern Africa (i.e. the first four genera listed above, plus the subsequently described *Kaokogeko*, Steyn and Haacke, 1966), supported this arrangement. Russell (1976), moreover, has demonstrated that all these genera, with the exception of *Ptenopus*, are closely related and are derivatives of the *Pachydactylus* radiation in the subregion.

#### *Chondrodactylus* Peters

Haacke (1976c) has recently reviewed the taxonomy and biology of this large, nocturnal, terrestrial gecko. He recognizes a single species with two races.

#### *Chondrodactylus angulifer angulifer* Peters

Distributed through the northern, north-western, western and central Cape Province. The region coincides closely with the 300 mm average rainfall zone.

#### *Chondrodactylus angulifer namibensis* Haacke X. *C. a angulifer* Peters.

Basically restricted to Namibia in the Namib and Pro-Namib, intergrades between the two races are known from Brandkaross and Lekkersing in the extreme north-western Cape Province.

#### *Palmatogeko rangei* Anderson

The range of this well-known Namib gecko is known to extend into the Richtersveld (Brandkaross, Bloeddrif and Sendelingsdrif). The lower Orange River may occasionally run dry and thus is no effective barrier to psammophilous forms. Haacke (1976a) has reviewed the monotypic genus.

#### *Colopus* Peters

Haacke (1976b) has reviewed the taxonomy and biology of this monotypic genus of small, terrestrial, nocturnal geckos. He recognizes two races, both of which occur in the northern Cape Province.

#### *Colopus wahlbergii wahlbergii* Peters

The nominate race extends into the northern Cape Province at Vanzylsrus and Gembok, in association with the Kalahari.

#### *Colopus wahlbergii furcifer* Haacke

The type locality of this new subspecies is Twee Rivieren on the Nossob River, Kalahari Gembok National Park, northern Cape Province. It is found in association with the more arid "dune areas" of the south-western Kalahari. It is characterized by a different colour pattern and a more pointed, subtriangular head.

#### *Phelsuma ocellata* (Boulenger)

Originally described as a species of *Rhotropus* this diurnal gecko, which is restricted to Little Namaqualand, was transferred to the monotypic genus *Rhotropella* by Hewitt (1937). It

has generally been assumed, and the new generic name implied, that *ocellata* was closely related to *Rhotropus*. However, Russell (1977) has demonstrated that Schmidt (1934) was correct in placing *ocellata* in *Phelsuma*, even though this generates an apparent zoogeographic anomaly.

*Phelsuma* is prevalent on Madagascar and the Indian Ocean Islands, although two species are also known from the East African coast. However, the south-west arid region of Madagascar shows a number of faunal and floristic similarities to the Karoo. The expansion and contraction of the Kalahari Desert has fragmented the ranges of a number of other genera and species of lizards, most notably that of *Platysaurus* (the species *capensis* is separated by 900 km from its nearest congener) and that of *Cordylus vittifer* (the subspecies *machadoi* Laurent from southern Angola is separated by nearly 1 000 km from the nominate race in the Transvaal). It may, in part, be responsible for the hiatus in the distribution of *Phelsuma*, that now results from the transfer of *ocellata* to the genus.

#### *Pachydactylus* Wiegmann

This is by far the largest genus of southern African lizards, and it has undergone an extensive radiation in the arid western regions. Many of the smaller genera of the region, i.e. *Palmatogecko*, *Colopus*, *Chondrodactylus*, *Kaokogecko* and *Rhotropus* are obviously derived from *Pachydactylus*-like ancestors, and illustrate the diverse habitats into which the group has radiated. The genus is undergoing active investigation by Dr G. McLachlan (South African Museum) and Mr W. Haacke (Transvaal Museum), and it will be some time before its taxonomy is stabilized. There have been numerous important taxonomic changes in the Cape representatives since FitzSimons' (1943) monograph, and these are summarized in Table 2.

#### *Pachydactylus austeni* Hewitt

A small, terrestrial gecko, the habits of which are very similar to those of *Palmatogecko rangei* (Haacke, 1976a). It is restricted to the coastal areas of Little Namaqualand, reaching as far south as Darling.

#### *Pachydactylus mariquensis mariquensis* A. Smith

A medium-sized, terrestrial gecko that lives in holes in the ground in karroid situations. Extensively distributed in the inland areas of the Cape Province, from Uitenhage to Worcester, and north to the Orange Free State.

#### *Pachydactylus mariquensis latirostris* Hewitt

Treated as a race of *mariquensis* by Loveridge (1947) and occurring in the north western Cape Province from Victoria West to Pofadder.

#### *Pachydactylus mariquensis macrolepis* FitzSimons

Known from the northern parts of Little Namaqualand (type locality: Springbokfontein). Loveridge (1947) suggested it may be synonymous with *P. amoenus*, which is known from the same region. The status of *macrolepis* itself is doubtful (McLachlan, *in litt.*)

#### *Pachydactylus amoenus* Werner

Known only from the type collected at Kamaggas, Little Namaqualand. This area is now relatively well-collected, and the status of this form has still to be resolved, particularly its relationship to *P. mariquensis macrolepis* (see above).

#### *Pachydactylus geitje* (Sparrman)

A small, attractive, terrestrial gecko, previously referred to as *P. ocellatus*. Distributed through the southern and western Cape, from Graaff-Reinet and Perdepoort in the Klein Winterhoekberg to the Cape Peninsula, and north to the Bokkeveld Mountains. It is also found on Robben Island.

## CHECKLIST OF CAPE LIZARDS

### *Pachydactylus monticolus* FitzSimons

A poorly known species, described from the Fransch Hoek mountains. Loveridge (1947) though it may be synonymous with *P. maculatus*, but this is considered doubtful by McLachlan (*in litt.*), who has collected rugose *P. geiije* to which *P. monticolus* is very similar. Whether the taxon deserves even subspecific recognition only further collecting will resolve.

### *Pachydactylus maculatus maculatus* Gray

This widely-distributed terrestrial gecko has a confused taxonomy which is in need of revision. Loveridge (1947) synonymized *P. microlepis*, *P. maculatus albomarginatus* and *P. capensis oculatus* with *P. maculatus*. De Waal (1978) has agreed that *oculatus* is referable to *maculatus* and not *capensis*, but recognizes it as a northern race (albeit tentatively, pending a full revision of the species). The nominate race is distributed mainly in the eastern regions of the Cape but extends as far west as Matjesfontein (Visser, 1979) and Matroosberg (McLachlan, *in litt.*)

### *Pachydactylus maculatus oculatus* Hewitt

A north-eastern race that occurs from Tarkastad District to Colesberg and Norvalspont and into the south-western Orange Free State (de Waal, 1978). *P. m. albomarginatus* is a synonym of this race.

### *Pachydactylus serval onscepcensis* Hewitt

McLachlan and Spence (1966) reviewed the *Pachydactylus weberi* and *P. serval* groups. They placed *montanus* in the synonymy of *serval*, and treated *onscepcensis* and *purcelli* as subspecies of *serval*. *P. s. onscepcensis* is found only in the far northwest of the Cape Province along the lower Orange River from Onseepkans to the Richtersveld.

### *Pachydactylus serval purcelli* Boulenger

A southern race of *serval*, that reaches as far south as Touwsrivier and Matjesfontein.

### *Pachydactylus weberi weberi* Roux

Three races of these small, rupicolous geckos are recognized. Loveridge (1947) treated *P. werneri* (from northern Namibia) as a subspecies of *weberi*, but this was not followed by either Mertens (1955) or McLachlan and Spence (1966). However, McLachlan (*in litt.*) now agrees with this arrangement and also considers the southern race *P. w. gariesensis* Hewitt to be untenable as enormous variation exists in the number of tubercles in southern specimens. The nominate race thus extends into the northern Cape as far as the Calvinia-Clanwilliam districts but is replaced in southern Namibia by *P. w. acuminatus* FitzSimons.

### *Pachydactylus punctatus amoenoides* Hewitt

Now known to enter the Cape in the region of the Richtersveld (De Hoop, Brandkarros, etc.) and the southern regions of the Kalahari Gemsbok National Park (Pianka, 1971). Mertens (1955) doubts the validity of this race, although Laurent (1964) considers *amoenoides* to be a full species. The group needs revision.

### *Pachydactylus rugosus rugosus* A. Smith

The taxonomy of this species has recently been reviewed by Loveridge (1947), Mertens (1955) and McLachlan (1979b). Loveridge (1947) resurrected the Namibian race *frater* but this has not been accepted by either Mertens (1955) or McLachlan (1979b). The latter author has transferred two subspecies of *P. capensis*, i.e. *P. c. formosus* and *P. c. barnardi*, to *rugosus* on the basis of similar colouration and the structure of the dorsal tubercles. The nominate race extends into the northern parts of Little Namaqualand in the vicinity of Onseepkans, Kakamas and Rietfontein.

*Pachydactylus rugosus formosus* A. Smith

A southern race found in the western Cape Province from Ceres District to the southern parts of Little Namaqualand. McLachlan (1979b) has restricted the type locality to Vredendal.

*Pachydactylus rugosus barnardi* FitzSimons

A central race of *rugosus* that is distributed throughout Little Namaqualand. It is sympatric with *P. capensis labialis* at Kamieskroon and Kleinseë. Broadley (1977b) has suggested that *barnardi* is a full species as its caudal scalation differs from that of *capensis* and *formosus*. He did not, however, compare its caudal scalation with typical *rugosus*.

*Pachydactylus capensis capensis* A. Smith

FitzSimons (1943) regarded *P. capensis* as polytypic with nine subspecies occurring in southern Africa, of which five entered the Cape Province. The studies of Loveridge (1947) and McLachlan (1979b), however, have reduced the number of Cape races to two. Broadley (1977b) has further reduced the number of races in the north-eastern range of *P. capensis*. A revision of the southern forms is needed. The nominate race extends north from the central Cape Province through Botswana and the Orange Free State to southern Angola and the northern Transvaal.

*Pachydactylus capensis labialis* FitzSimons

This western race is recorded from Little Namaqualand and may deserve specific recognition (McLachlan, *in litt.*)

*Pachydactylus mentalis* Hewitt

Known from the south-eastern Cape Province, from Graaff-Reinet to Tarkastad, this species was treated as a subspecies of *P. capensis* by Loveridge (1947). However, de Waal (1978) noted that the snout scales of *mentalis* differ from those of *capensis* and that its status requires investigation.

*Pachydactylus namaquensis* (Sclater)

A large rupicolous gecko that is closely related to the following two species. It is found in Little Namaqualand and southwards into the western Karoo. A specimen (now in the Transvaal Museum) recently collected from the Langeberg Mountains (3321 DC) is a considerable southern extension (R. Boycott, *pers. comm.*).

*Pachydactylus bibroni* A. Smith

A wide-ranging large gecko, the range of which extends from the northern and western Cape Province to Angola and Tanzania. Loveridge (1947) recognized three subspecies, *bibroni*, *turneri* and *pulitzeriae*, but these have not been accepted by Broadley (1966) or de Waal (1978). The problem requires further investigation.

*Pachydactylus laevigatus laevigatus* Fischer

A large gecko closely related to and often confused with the previous species. The nominate race extends into the northern Cape reaching Marydale in the east and the vicinity of Prieska and Springbok in the south. It extends north through Namibia to southern Angola, being replaced by the race *P. l. fitzsimonsi* (Loveridge, 1947) in Damaraland.

*Lygodactylus* Gray

An ancient genus that may be one of the few African lizards to have been directly affected by the upheavals of continental drift. It is well represented on Madagascar, whilst two species have also been recently described from South America. Although referred to a separate genus

## CHECKLIST OF CAPE LIZARDS

(*Vanzoia*; Smith *et al.*, 1977) these Neotropical representatives seem only doubtfully distinct from *Lygodactylus* (Broadley, *in litt.*). One species (*L. capensis*) has even been found embedded in amber (Kluge, 1967). The taxonomy of these small, diurnal geckos, notoriously difficult, has been recently reviewed by Pasteur (1964).

### *Lygodactylus bradfieldi* Hewitt

This species, described by Hewitt in 1932, was treated as a western race of *L. capensis* by FitzSimons (1943) but fared worse under Loveridge (1947) who placed it in the synonymy of the latter. Pasteur (1964) re-elevated it to a full species but difficulty is still experienced in separating the two forms. It is found at various localities in the northern and north-western Cape, from Kimberley to the Richtersveld.

A specimen of *L. capensis* in the collection of the Addo Elephant National Park presumably represents a translocation, possibly in a game crate, from the Kruger National Park.

### *Ptenopus* Gray

Previously considered to be monotypic, containing the single species *garrulus* (FitzSimons, 1943). Two further species (*carpi* and *kochi*) have subsequently been described from Namibia. The two subspecies of *garrulus* were synonymized by Brain (1962) but, more recently, Haacke (1975) has resurrected *maculatus*. Both races occur in the Cape Province.

### *Ptenopus garrulus garrulus* (A. Smith)

This small, terrestrial, pad-less gecko is widely distributed in those areas of southern Africa that are covered in Kalahari sand and receive less than 500 mm average rainfall. The range extends into the northern Cape Province, reaching as far as the Orange Free State border near Lemoenboord (de Waal, 1978).

### *Ptenopus garrulus maculatus* Gray

A western form that extends through Namibia and the north-western Cape Province. Somewhat surprisingly, specimens were recently collected near Calitzdorp in the Little Karoo (Oelofsen and Kruger, 1976). This gecko may be more widespread in the central Cape Province than realized.

### *Phyllodactylus* Gray

A wide ranging genus found in Tropical America, Mediterranean Europe, Africa and Australia. The taxonomy of the southern African forms remains confused.

### *Phyllodactylus peringueyi* Boulenger

The status of this species remains problematic. The types, which remain the only known specimens, are labelled as from Little Namaqualand and Port Elizabeth. That labelled as from Little Namaqualand was accessioned with a *Crotaphopeltis hotamboeia* which was listed as coming from the same area. As the herald snake is not known from Little Namaqualand this locality must be in doubt (McLachlan, *pers. comm.*). However, the remaining locality (Chelsea Point, near Port Elizabeth) is in a coastal dune region with little emergent rock. It is now extensively invaded by exotic Australian *Acacia* and searches for this lizard at this spot by both McLachlan (*pers. comm.*) and the author have proved fruitless. Hewitt (1937) has suggested that the specimens are American. Their true identity, if not South African, remains unknown.

### *Phyllodactylus porphyreus* (Daudin)

Known from the south and south-western Cape Province and extending east as far as Cape St Francis and north to Little Namaqualand. FitzSimons (1943) recognized three races. However, Loveridge (1947) synonymized the south coast form (*cronwrighti*—known from

Knysna to Cape St Francis) with typical *porphyreus*. The status of the west coast race *namaquensis*, which is known only from Little Namaqualand, is also in need of study. McLachlan (*in litt.*) doubts the validity of the Bitterfontein locality (from which the type of *namaquensis* comes). If correct, then Nieuwoudtville is the northern limit for the species.

*Phyllodactylus lineatus lineatus* Gray

A small, rupicolous gecko known from the south and central (Laingsburg) Cape Province and north along the west coast to Little Namaqualand.

*Phyllodactylus lineatus rupicolous* FitzSimons

The validity of this northern form is doubtful as it is described from some localities listed for typical *lineatus* (i.e. Springbok and Kamaggas). Haacke (1965) could also find no differences between Oranjemund specimens and the typical race.

*Phyllodactylus lineatus essexi* Hewitt

This eastern form seems well-defined. Its range is now known to extend further west (Suurberg) than the type locality at Hounslow near Grahamstown.

*Phyllodactylus microlepidotus* FitzSimons

This large, nocturnal gecko has, since its original description in 1939, only recently been rediscovered (McLachlan, 1979c; Visser, 1979). All known specimens come from the Cedarberg, mostly at Pakhuis Pass.

*Afroedura* Loveridge

This genus was described by Loveridge (1944a) to accommodate African geckos previously referred to the genus *Oedura* by FitzSimons (1943). *Oedura* is now restricted to Australia. Loveridge (1947) synonymized a number of the species listed in FitzSimons (1943). However, the taxonomy of the genus is still not stabilized and a much needed revision is presently in progress (Onderstall, 1975).

*Afroedura africana namaquensis* (FitzSimons)

Known only from Little Namaqualand. Treated by FitzSimons (1943) as a full species, this form has been reduced to a subspecies of *africana* by Haacke (1965) who described a new subspecies, *tirasensis*, from Great Namaqualand, intermediate in characteristics between typical *africana* and *namaquensis*.

*Afroedura nivaria* (Boulenger)

Loveridge (1947) synonymized *Oedura amatolica* with *Afroedura nivaria*. The characters used by Hewitt to differentiate *amatolica* are quite minor. The distribution of *A. nivaria* thus closely parallels that of *Pseudocordylus melanotus subviridis* being found in the Eastern Cape Province in the vicinity of the Katberg and Amatola Mountains and thence northwards along the Drakensberg escarpment.

*Afroedura tembulica* (Hewitt)

Known from the mountains of the south-eastern Cape Province, from Tembuland (from which the species derives its name) to the Queenstown District. The relationship of this species to *nivaria* and *karroica* requires investigation.

*Afroedura karroica karroica* (Hewitt)

Typical *karroica* was known to FitzSimons (1943) by only a poorly preserved type of vague locality (Albany District). Hewitt's subspecies *A. k. wilmoti* was recognized by Fitz-



## CHECKLIST OF CAPE LIZARDS

Simons (1943) but was only dubiously separable from the nominate race due to the latter's vague provenance. Loveridge (1947) synonymized both forms, and the nominate subspecies is now considered to range through the inner regions of the Eastern Cape Province, from Graaff-Reinet to Tarkastad.

*Afroedura karroica halli* (Hewitt)

Loveridge (1947) treated *halli* as a race of *karroica* although FitzSimons (1943), who treated the form as a full species in his monograph, considered it might only be a subspecies of *nivaria*. Like *tembulica* it is restricted to the mountainous regions of the north-east-ern Cape Province in the vicinity of Herschel.

### INFRAORDER: ANGUIMORPHA SUPERFAMILY: PLATYNOTA

#### Family: Varanidae

With the exception of the anguid genus *Ophisaurus* which ranges into North Africa, three species of *Varanus* are the only anguimorph lizards found on the African continent. *Varanus griseus* is restricted to Saharan Africa, whilst the remaining two species occur almost throughout the continent.

*Varanus niloticus niloticus* (Linnaeus)

The race *ornatus* replaces typical *niloticus* in the West African rain forests. Along the south-east coastal region the most westerly record of *niloticus* in the Cape Province appears to be Patensie in the Gamtoos River Valley. In the north it extends along the Orange River to Vioolsdrif (*pers. obser.*) and possibly along its whole length, however, it is absent from the central and southwest Cape.

*Varanus exanthematicus albigularis* (Daudin)

Entering the Cape Province in the northern, central and eastern regions, its southern and western limits remain unknown. J. Greig (*pers. comm.*) has recorded the species from Beaufort West.

### INFRAORDER: IGUANIA

A group of generalized, primarily arboreal lizards, some of which have become secondarily terrestrial or even semi-aquatic. None have become serpentiform, with elongate body or reduced limbs. Three living families are recognized. The Iguanidae are the most primitive and appear to have been the ancestral stock for the Agamidae. The chamaeleons in turn may have been derived from the latter family. Iguanids are not now known from mainland Africa, although two genera occur on Madagascar. They have been displaced by their descendants, the agamids.

#### Family: Chamaeleonidae

The generic status of the dwarf viviparous chamaeleons of the south and east coast of southern Africa remains in a state of flux. Hillenius (1959) considered all the dwarf chamaeleons placed by FitzSimons (1943) in the genus *Microsaura* (including the Cape forms *taenio-broncha*, *caffer*, *pumila*, *damarana*, *gutturalis* and *ventralis*) to be but subspecies of the widespread species *Chamaeleo pumilus*. However, Raw (1976, 1978) has re-elevated these forms to specific rank and revived the earlier generic name *Bradypodion* Fitzinger. This name has not been used in over 130 years and, although it possesses priority over *Microsaura* Gray, it could have been suppressed in favour of the more recently used and more widely known junior

synonym. These chamaeleons are usually found in allopatric populations and species limits are difficult to define. Raw's (1976) proposal to elevate all forms to specific rank is followed here for convenience. However, it is probable that a number of these forms will prove to be but local races, or even synonyms, as their biology and distribution become more well known.

*Bradypodion taeniobronchum* (A. Smith)

Apparently confined to the area of Algoa Bay, but very rare. Searches at Schoenmaker's Kop and Van Stadens River for further specimens have proved fruitless.

*Bradypodion damaranum* (Boulenger)

Perversely named as the species is only known from the coastal region around Knysna, Tsitsikama and George.

*Bradypodion pumilum* (Daudin)

Its distribution is centred in the Western Cape Province, from the Cape Peninsula northwards to Clanwilliam and eastwards to Bredasdorp.

*Bradypodion occidentale* (Hewitt)

Visser (1979) records this species from Melkbosstrand, 25 km north of Cape Town, a considerable southerly extension from its previous record in Little Namaqualand.

*Bradypodion ventrale* (Gray)

Recorded from the Eastern Cape Province from Port Elizabeth to Port Alfred and inland as far as Queenstown and the Katberg (FitzSimons, 1943). Visser's (1979) record of this form from Fort Beaufort (an area from which FitzSimons records *karroicum*) may validate the specific status of the latter taxon, but this requires confirmation.

*Bradypodion karroicum* (Methuen and Hewitt)

As its name implies, extends through the karroid areas of the Cape Province from Fort Beaufort (see note under *B. ventrale*) to Grootvadersbosch and inland as far as Nieuwoudtville and Victoria West (Visser, 1979).

*Bradypodion gutturale* (A. Smith)

Poorly known and apparently confined to the Worcester and Robertson Districts.

*Chamaeleo Laurenti*

The genus is represented in the Cape Province by two species. *Chamaeleo laevigularis* Muller was described from East London, Cape Province, but FitzSimons (1943) could not refer it to any southern African forms and treated it as a "*species auctorum*". Hillenius (1963) has subsequently compared the type to *C. johnstoni* from the Congo and found them to be conspecific.

*Chamaeleo namaquensis* A. Smith

A large terrestrial chamaeleon that ranges into Little Namaqualand. The sexes are dichromatic (Robertson, 1978).

*Chamaeleo dilepis dilepis* Leach

The flap-necked chamaeleon enters the Cape Province in the Kalahari Gemsbok National Park. It is known from a specimen collected at Nossob (Haacke *pers. comm.*). De Waal (1978) records a specimen from Bloemhof Dam, on the Orange Free State border, and it may enter the Cape in this vicinity as well. Basically, though, its distribution extends north of the region under discussion through the savannah regions of southern and eastern Africa. Broadley (1966)

## CHECKLIST OF CAPE LIZARDS

and Hillenius (1959) have discussed the taxonomy of the many described races of *C. dilepis*. All are of doubtful validity, with the exception of *C. d. ruspolii* Boettger from Somalia. Trinomials are thus retained.

### Family: Agamidae

Represented in Africa by only two genera, *Uromastix* and *Agama*. *Uromastix* is terrestrial and restricted to Saharan Africa, whilst *Agama* has arboreal, rupicolous and terrestrial forms and ranges throughout most of the savannah regions of the continent.

#### *Agama* Daudin

Represented in the Cape Province by three species, although the taxonomy of one species, *A. hispida*, is chaotic and it may be polyphyletic.

#### *Agama atra atra* Daudin

One of the very few lizards the distribution of which encompasses the whole of the Cape Province. Trinomials are necessary as Mertens (1955) has transferred *knobeli* (known from Great Namaqualand) from *anchietae* to *atra*.

#### *Agama anchietae* Bocage

Similar in habits to *atra*, and extending from the north-western Cape Province into Namibia.

#### *Agama hispida* (Linnaeus)

FitzSimons (1943) recognized six subspecies of *hispida*, but many of these forms occur at the same localities. Broadley (1966) rejected all subspecies pending a full revision of the species. This is presently being undertaken by Dr G. McLachlan (South African Museum). It appears that *aculeata* is a full species and differs from *hispida* in having an enlarged ear hole. The relationship of the other forms to these two species requires further investigation (McLachlan, *per. comm.*).

## INFRAORDER: SCINCOMORPHA

These lizards are almost cosmopolitan in distribution and diurnal in habit. The activity patterns of many fossorial forms, however, require investigation. Six families are included of which three families have representatives in southern Africa, i.e. the Lacertidae, Scincidae and Cordylidae.

### Family: Lacertidae

A large family that is common in the Palaearctic region and is well represented in the arid and savannah areas of the Afro-tropical region. Six genera occur in the Cape Province.

#### *"Lacerta" australis* Hewitt

The rarest lizard in the Cape Province, known only from the type collected on the Matroosberg near Ceres. Arnold (1973) has suggested that this species and *"Lacerta" rupicola* FitzSimons from Lake Fundusi in the northern Transvaal are not congeneric with Palaearctic *Lacerta sensu stricta*. It is probable that a new genus will have to be erected to accommodate them. Their relationship to *Tropidosaura* is presently being investigated.

#### *Tropidosaura* Fitzinger

A small genus of terrestrial, montane lacertids that are endemic to southern Africa. Four species are currently recognized, two of which occur in the Cape Province.

*Tropidosaura gularis* Hewitt

A montane form that is now known to extend along the southern Cape Fold Mountains from Table Mountain to the Port Elizabeth District.

*Tropidosaura montana montana* (Gray)

A wide-ranging, but poorly-known lizard, with three recognized races. The typical race is distributed in the western and south-western Cape from Table Mountain north to the Cold Bokkeveld and east to Heidelberg.

*Tropidosaura montana rangeri* Hewitt

Known from the tops of the Katberg and Amatola Mountains down to the sea cliffs at Hamburg in the Eastern Cape Province. The large distribution gaps between this race and the typical form in the west and *T. m. natalensis* (described by FitzSimons from the Natal Drakensberg in 1947) in the east are probably due to poor collecting and zones of intergradation (if any) have yet to be established.

*Nucras* Gray

Very secretive lacertids the taxonomy of which is confused due to the paucity of specimens and the great overlap in "diagnostic" characters in the genus. Broadley (1972) has reviewed the *tessellata* group and placed great emphasis on colour pattern.

*Nucras lalandi* (Milne-Edwards)

A large *Nucras* with a thick tail. Widely distributed in the eastern regions from Knysna to Natal and the Transvaal. Incorrectly called *N. delalandii* by FitzSimons (1943).

*Nucras taeniolata taeniolata* (A. Smith)

Erected to full specific status by Broadley (1972). Restricted to a small isolated, possibly relic population centred around Grahamstown in the Eastern Cape Province.

*Nucras taeniolata ornata* Gray

A wide-ranging race that shows considerable regional variation. In the Cape Province it enters the Kimberley region and reaches as far south as Burgersdorp. *Nucras intertexta holubi* and *N. i. damarana* are synonyms of *ornata* (Broadley, 1972).

*Nucras intertexta* (A. Smith)

A Kalahari species that extends into the northern Cape Province in the Kimberley region.

*Nucras tessellata tessellata* (A. Smith)

A western Cape form that extends from Namibia to Worcester. A rufous-grey colour variety (var *elegans*) occurs along the eastern border of this subspecies (i.e. Caledon, Marydale, Calvinia, etc.). A further colour variety (var. "*T*") shows affinities in its dorsal colour pattern to *taeniolata taeniolata* of the eastern Cape. As it occurs in sympatry with typical *tessellata* at Klipfontein and Steinkopf it cannot be treated as a distinct subspecies. Broadley (1972) has treated this form as a variety of typical *tessellata*, although he notes it may be a distinct species or a western subspecies of *taeniolata*. The problem remains unsolved.

*Nucras tessellata livida* (A. Smith)

Inhabiting the Karoo areas of the Cape Province, from Matjesfontein to Port Elizabeth. It separates the typical races of *tessellata* and *taeniolata* and obscures the relationship of *tessellata* var "*T*" (see above).

## CHECKLIST OF CAPE LIZARDS

### *Eremias* Wiegmann

A very wide ranging genus previously considered to extend throughout Africa into south-eastern Europe and through western and central Asia to China and Korea. Boulenger (1921) in his *Monograph of the Lacertidae* divided *Eremias* s.l. into 5 "Sections" (Subgenera). Those relevant to southern Africa are *Lampreremias* (including *lugubris*) and *Mesalina* (including *namaquensis*, *undata*, *lineoocellata*, *laticeps* and *burchelli*). *Eremias* s.s. is restricted to south-east Europe and Asia. Scherbach (1975) treats Boulenger's "Sections" as full genera, belonging to the subfamily *Eremiinae*. Loveridge (1957) pointed out that the earliest available generic name for southern African "*Eremias*" is *Heliobolus* Fitzinger 1843 (type by original designation: *Lacerta lugubris*). At present it seems best to recognize *Heliobolus* and *Mesalina* as subgenera of *Eremias* pending an investigation of their relationships (Broadley, pers. comm.).

### *Eremias (Heliobolus) lugubris* (A. Smith)

Distributed throughout the Kalahari and neighbouring regions and recently recorded in the Cape Province from near Vryburg and Tweerivieren.

### *Eremias (Mesalina) namaquensis* Duméril and Bibron

Extending from Little Namaqualand across the northern regions of the Cape Province to Graaff-Reinet and Cradock in the eastern Cape.

### *Eremias (Mesalina) laticeps* A. Smith

Extending across the karroid regions, from Graaff-Reinet to Little Namaqualand, and across the Orange River into Great Namaqualand. Mertens (1955) revived the name for *Lacerta capensis* (= *Eremias capensis*) as the name is preoccupied by *Lacerta capensis* Sparrmann 1783 (= *Varanus n. niloticus*).

### *Eremias (Mesalina) undata undata* (A. Smith)

Closely related to *E. namaquensis* and mainly restricted to Namibia, although it ranges into Little Namaqualand and the northwest Cape Province. A colour variety *inornata* was recognized by FitzSimons (1943) in the southern part of the range of *undata*. However, it occurs in a scattered pattern through the range of *undata* and cannot be considered as a valid subspecies. Trinomials are required, nonetheless, as Mertens (1955) has described two subspecies (*rubens* and *gaerdesi*) from the Waterberg and north-west regions of Namibia respectively.

### *Eremias (Mesalina) burchelli* Duméril and Bibron

A montane form that extends across the southern Cape from Cape Agulhas and the Cedarberg to Queenstown and on to the Natal Drakensberg.

### *Eremias (Mesalina) lineoocellata lineoocellata* Duméril and Bibron

A wide-ranging subspecies that enters the Cape Province in the northern regions around Kimberley.

### *Eremias (Mesalina) lineoocellata pulchella* Gray

The main subspecies in the Cape Province, extending in a wide belt from Little Namaqualand and the Western Cape Province, through the central and southern karroid areas to the Eastern Cape Province. Replaced in Great Namaqualand by the spot-less subspecies *inocellata* (Mertens, 1955).

### *Ichnotropis* Peters

A small genus of rough-scaled, terrestrial lacertids, represented in southern Africa by three species.

*Ichnotropis squamulosa* Peters

Broadley (1976a) has shown that these lizards are very short-lived, hatching and growing to sexual maturity in six months and then dying soon after reproduction. *I. capensis* has a similar abbreviated life history, but the cycles of the two species are phased such that their eggs hatch at different times. This avoids competition for the same resources. Mainly distributed north of the Cape Province, it has recently been recorded from the Kalahari Gemsbok National Park (Pianka, 1971).

*Meroles* Gray

Mertens (1955) demonstrated that *Scaptira* Wiegmann, to which FitzSimons (1943) referred the following species, is restricted to Central Asia. The next available generic name is that of *Meroles* Gray 1938. Six monotypic species are recognized, of which four range into the Cape Province.

*Meroles suborbitalis* (Peters)

Extending from the central Karoo west and north through Little Namaqualand and Gordonia.

*Meroles knoxii* (Milne-Edwards)

A common lizard throughout its range which extends from the western Province northwards through Little Namaqualand to Namibia (Lüderitz). Haacke (1965) has demonstrated that the northern subspecies *pequensis* (Hewitt) is invalid.

*Meroles ctenodactylus* (A. Smith)

A larger, slower-moving species that extends from Little Namaqualand and the adjacent Karoo to just north of the Orange River. It reaches as far south as the Zout Rivier on the west coast (McLachlan, *in litt.* ).

*Meroles cuneirostris* (Stauch)

A psammophilous species well adapted to life in the Namib Desert, the range of which just extends into Little Namaqualand (Brandkaros, Holgat River Mouth, etc.).

**Family: Scincidae**

Greer (1970a) has revised the family on the basis of osteological characters. Four subfamilies are recognized: Scincinae (with approximately 28+ genera, 182 species), Feylininae (2 genera, 4 species), Acontinae (3 genera, 16 species) and Lygosominae (40+ genera, 600+ species). The Scincinae are considered to have independently given rise to all three other subfamilies. The Acontinae and Feylininae are both viviparous, burrowing groups, whilst the Lygosominae is composed of the most numerous, diverse and advanced skinks. All subfamilies, with the exception of the Feylininae (which is restricted to west and central Africa), are found in the Cape Province.

**Acontinae**

Distributed throughout southern Africa, with an isolated population in south-east Kenya. Malagasy *Acontias* (*holomelas* and *hildebrandti*) were referred to the new scincine genus *Malacocentias* by Greer (1970a). Three genera are recognized in southern Africa; *Acontias* (7 species), *Typhlosaurus* (8 species) and the monotypic *Acontophiops*.

*Acontias* Cuvier

The genus was revised by Broadley and Greer (1969), who recognized seven species, all of which are found in the Cape Province.

## CHECKLIST OF CAPE LIZARDS

### *Acontias plumbeus* Bianconi

A very large burrowing skink that inhabits the tropical lowlands of south-eastern Africa. An isolated, possibly relic, population occurs in the eastern Cape, around East London.

### *Acontias breviceps* Essex

Previously treated by FitzSimons as a subspecies of *A. plumbeus*. It has a discontinuous distribution at high altitudes along the eastern escarpment and occurs in the eastern Cape around the Hogsback and Katberg.

### *Acontias gracilicauda gracilicauda* Essex

Treated as a subspecies of *A. plumbeus* by FitzSimons, but differs from it in having a small post-temporal fenestra and a strongly tapering tail. Found in the eastern Cape as far south as Port Elizabeth, extending northwards into higher altitudes on the high veld of the Orange Free State and Transvaal and into the northern Cape as far as Kuruman.

### *Acontias gracilicauda namaquensis* Hewitt

A poorly defined western race found in Little Namaqualand. It was also previously treated as a subspecies of *A. plumbeus* by FitzSimons (1943).

### *Acontias percivali tasmani* Hewitt

Although previously treated as a race of *A. plumbeus* by FitzSimons (1943), *tasmani* differs from this species in having no post-temporal fenestra. The species has a remarkable discontinuous distribution and typical *percivali* is found in the vicinity of Voi in south-eastern Kenya. The race *tasmani* has a very restricted range in the Eastern Cape Province from Port Elizabeth to King William's Town.

### *Acontias meleagris meleagris* Hewitt

A very variable form that ranges along the south-west Cape coast from Cape Town to Knysna and inland as far as Fraserburg in the Karoo.

### *Acontias meleagris orientalis* Hewitt

An eastern race that extends from Cape St Francis to the Transkei. FitzSimons recognized a separate race *lineicauda* from the Port Elizabeth—Grahamstown region. Broadley and Greer (1969) conservatively treated this form as a localized "morph" of *orientalis* but noted that it was smaller and more slender and inhabits the dry habitats of the Sundays River and Great Fish River valleys. Its status has still to be resolved.

### *Acontias lineatus lineatus* Peters

Inhabiting the interior of the Western Cape Province from Matjesfontein north to Kakamas in the west and Hopetown in the east, then across the Orange River as far north as Lüderitz and Keetmanshoop. The race *orangensis* Hewitt is a synonym of typical *lineatus* (Broadley and Greer, 1969).

### *Acontias lineatus tristis* Werner

Restricted to Little Namaqualand. Treated as only a variety of *lineatus* by FitzSimons but elevated to subspecific level by Broadley and Greer (1969).

### *Acontias lineatus grayi* Boulenger

A very localized race (known only from the type locality—Graafwater, between Clanwilliam and Lambert's Bay, south-western Cape), the status of which is still problematic.

*Acontias litoralis* Broadley and Greer

A small species related to *A. lineatus* and restricted to the western Cape coastal strip from Daberas to Elandsbaai.

*Typhlosaurus* Wiegmann

Highly specialized, limbless, fossorial skinks, of which FitzSimons (1943) recognized eight species. Haacke (1964) described a greatly attenuated species (*braini*) from the Namib Desert, whilst Broadley (1968) in revising the whole genus, placed *plowesi* in the synonymy of *meyeri*, and thus returned the total number of species in the genus to eight. The genus ranges across the northern regions of southern Africa, with five species occurring in the western Cape region.

*Typhlosaurus lineatus lineatus* Boulenger

A Kalahari species that extends into the northern Cape Province in the Kalahari Gemsbok National Park and thence south to Witdraai and Vanzylsrus.

*Typhlosaurus garipeensis* FitzSimons

Related to *lineatus* and found in the northern Cape Province from Upington to the Kalahari Gemsbok National Park.

*Typhlosaurus meyeri* Boettger

An attenuated species that inhabits the coastal regions of southern Namibia, from Lüderitz south to the Richtersveld and Little Namaqualand. Broadley (1968) synonymized *T. plowesi* FitzSimons with this species.

*Typhlosaurus caecus* (Cuvier)

Another attenuated species, the one that extends the furthest south. Distributed in the coastal areas of the Western Cape Province from Edgemead, Cape Town (Visser, 1979), northwards, possibly as far as Port Nolloth (where it is known from a single specimen), but certainly as far as Lambert's Bay.

*Typhlosaurus vermis* Boulenger

Closely related to, and possibly conspecific with *T. caecus*. Extending from Alexander Bay south to the Spoegrivier and inland as far as Putsonderwater. Broadley's (1968) reference to Lambert's Bay is questioned by McLachlan (*in litt.*).

### Scincinae

Basically Old World in distribution, with six genera occurring in sub-Saharan Africa. Only *Scelotes* extends into the Cape Province.

*Scelotes* Fitzinger

A large group of semi-fossorial to fossorial small skinks. The genus shows an interesting progression from species with small but well-developed limbs to limbless species. It has undergone extensive partitioning (Greer, 1970b) since FitzSimons' monograph (1943). However, all the new genera are extralimital to this discussion. There has been no alteration in the taxonomy of the Cape species since FitzSimons' monograph (1943) and the genus remains in urgent need of revision.

*Scelotes anguina* (Boulenger)

Coastal areas of the Eastern Cape Province from Port Elizabeth to Peddie.



## CHECKLIST OF CAPE LIZARDS

### *Scelotes capensis* (A. Smith)

Known from Little and Great Namaqualand.

### *Scelotes caffer* (Peters)

Apparently common in the Fish River Valley of the Eastern Cape Province and extending through the Karoo to Little Namaqualand.

### *Scelotes kasneri* FitzSimons

Known only from the type locality, i.e. Lambert's Bay, Clanwilliam District, Western Cape Province.

### *Scelotes bipes bipes* (Linnaeus)

Restricted to the south-western Cape Province from Mossel Bay to the Cape Peninsula.

### *Scelotes bipes sexlineatus* (Harlan)

Recorded from Port Nolloth and Kleinsee in Little Namaqualand and south to Clanwilliam and Calvinia.

### *Scelotes gronovii* (Daudin)

Inhabiting the coastal regions of the south-western Cape Province from Dassen Island to Lambert's Bay.

### *Scelotes bicolor* (A. Smith)

Although the type locality of this species is given as Little Namaqualand, no further specimens have been collected. FitzSimons (1943) questioned the validity of the species as no other legless *Scelotes* are known from the western Cape. It is very closely related to, and possibly conspecific with, *S. arenicola* which is known from Zululand and Mozambique.

## Lygosominae

An extremely widespread group that is particularly well-represented in, and probably originated within, the Australasian region. In southern Africa it is represented by the genera *Mabuya*, *Panaspis* (= *Ablepharus* Fitzinger and *Afroablepharus* Greer), *Lygosoma* (= *Riopa*) and *Cryptoblepharus*. Only the first occurs in the Cape Province.

### *Mabuya* Fitzinger

A wide-ranging genus distributed throughout Africa and Madagascar and found also in south-eastern Asia, Central and South America and the Caribbean. The most common skinks in the Cape Province, with no less than nine recognized species, some of which have local races.

### *Mabuya capensis* (Gray)

A large, thick-bodied skink that is distributed throughout the Cape Province, although it is rarer in the arid, western regions. It is now known to extend north of the Limpopo as far as Zambia.

### *Mabuya occidentalis* (Peters)

Closely related to the previous species, but of generally lighter build. In the Cape it is restricted to karroid regions, from Cradock and Beaufort West, extending north-west through Little Namaqualand and Namibia to southern Angola.

*Mabuya homalocephala homalocephala* (Wiegmann)

The nominate race of this medium-sized, terrestrial species extends along the coastal regions and Cape Fold Mountains of the western and south-western Cape, from Little Namaqualand to Knysna.

*Mabuya homalocephala peringueyi* Boulenger

A northern race found in Little Namaqualand. The record from Namibia is incorrect (McLachlan, *in litt.*).

*Mabuya homalocephala smithii* (Gray)

Extending along the eastern Cape coastal regions from Garcia Pass, Langeberg, to the Transkei. It is now known to extend inland as far as Rubidge Kloof, north of Graaff-Reinet. There appears to be a fairly extensive overlap with the nominate race from Knysna to Swellendam that requires investigation.

*Mabuya striata* complex

The taxonomy of this problematic group has recently been stabilized by Broadley's revision of the complex (1977a). Mertens (1955) split the previously monotypic *striata* (FitzSimons, 1943) into three races, i.e. nominate *striata*, *sparsa* and *spilogaster*. Sympatry between *spilogaster* and *sparsa* in the Kalahari Gemsbok National Park was noted by Broadley (1969) who in his subsequent revision of the complex (1977a) recognized two further races of *striata*, i.e. *wahlbergi* and *punctatissimus*. Three of these taxa occur in the Cape Province.

*Mabuya striata punctatissimus* (A. Smith)

Extending just into the northern Cape in the vicinity of Mafeking and Aliwal North. Intergrades between this and the following race occur in the vicinity of Vanzylrus.

*Mabuya striata sparsa* Mertens

A robust, dark subspecies common in the Kalahari Gemsbok National Park and extending into neighbouring Namibia and Botswana.

*Mabuya spilogaster* (Peters)

A robust, speckled species that is commonly found on *Acacia* trees and is thus ecologically separated from sympatric *striata*. It extends from southern Angola through Namibia and western Botswana into the northern Cape Province, reaching as far east as Kimberley.

*Mabuya sulcata sulcata* (Peters)

Considered monotypic by FitzSimons (1943). Mertens (1955) recognized a new race, *nigra* from Lüderitz in Namibia, and resurrected Boulenger's *ansorgii* as a separate race for Angolan material. Only the nominate race occurs in the Cape and is found throughout the Karoo and adjoining regions, from Little Namaqualand to Perdepoort in the Klein Winterhoekberg.

*Mabuya variegata variegata* (Peters)

The confused taxonomy of these small skinks is too lengthy to be dealt with here and, moreover, has been admirably reviewed by Broadley (1975). In summary the species *damarana* and *varia* have long been misidentified. Two forms occur and Mertens (1955) resurrected the name *longiloba* after demonstrating that the type of *damarana* was a synonym of *varia*. Subsequently Broadley (1975) has shown that *longiloba* is a synonym of *Euprepes variegatus*, and the name must change again. He also recognized a northern subspecies. The nominate race extends along the west coast of southern Africa south of the Cunene River to as far south as the Clanwilliam District in the western Cape. It also occurs eastwards through the Karoo to Kimberley and the Albany District.

## CHECKLIST OF CAPE LIZARDS

### *Mabuya variegata punctulata* (Bocage)

A northern and eastern race that extends into the northern Cape Province in the region of Mafeking and the Kalahari Gemsbok National Park. In addition de Waal (1978) refers to this race specimens from Rietfontein on the border of the Orange Free State and the north-eastern Cape Province even though typical *variegata* occurs at Zastron. It is possible that *punctulata* and *variegata* are not conspecific.

### *Mabuya varia* (Peters)

Due to confusion with *damarana* (= *variegata*, see above) this species now has a much more restricted range in southern Africa than that given in FitzSimons (1943). The species ranges southwards from Sudan and Somalia but only extends into the south-eastern corner of the Cape Province in the vicinity of Grahamstown and Port Elizabeth.

### *Mabuya acutilabris* (Peters)

A small, well-defined western species that extends into the Cape Province only in the northern tip of Little Namaqualand.

## Family: Cordylidae

The family now includes the plated lizards and related forms which were treated by FitzSimons (1943) as a separate family but should now be treated as a subfamily of the Cordylidae (McDowell and Bogert, 1954). The family is closely related to the Lacertidae but there is uncertainty as to whether it is ancestral to, or derived from these lizards. The family is basically distributed throughout sub-Saharan Africa, although a number of Gerrhosaurines occur on Madagascar.

## Cordylinae

Four genera are recognized, of which all occur in the Cape Province.

### *Chamaesaura* Schneider

A group of elongate, serpentiform cordylids that show varying degrees of limb-reduction and which are amazingly conservative in morphology. Three species are recognized, of which two occur in the Cape Province.

### *Chamaesaura aenea* (Wiegmann)

A montane form that reaches its southern limit in the vicinity of the Amatola Mountains near Cathcart and Tarkastad in the north-eastern Cape Province.

### *Chamaesaura anguina anguina* (Linnaeus)

The most widespread *Chamaesaura* in the Cape Province, extending in a wide belt across the more humid regions of the southern Cape from Kei Mouth to Cape Town. It is separated by nearly a 1 000 km from the northern race *C. a. tenuior* (which was treated as a separate species by FitzSimons, 1943) found in East Africa.

### *Platysaurus* A. Smith

These greatly flattened, highly specialized corylids have undergone rapid speciation in the rocky areas of south-eastern Africa, and have been extensively studied by Broadley (1978). A single, relic species occurs along the lower Orange River, 900 km from its nearest neighbour, *Platysaurus g. guttatus*, in the Limpopo River basin.

*Platysaurus capensis* A. Smith

Found along the lower Orange River, west of Aughrabies Falls, extending into Namibia along the Fish River Canyon and southwards to Garies in the Cape Province. Broadley (1978) has discussed the possibility that the population at Aughrabies Falls may deserve subspecies recognition.

*Pseudocordylus* A. Smith

There have been numerous alterations to the concept of *Pseudocordylus* since FitzSimons' (1943) monograph and the status of the genus and its constituent species has still to be resolved. *Pseudocordylus* is obviously closely related to *Cordylus* but the boundaries between the two genera are vague and they may indeed be congeneric. In addition, the species presently placed in *Pseudocordylus* may in fact be polyphyletic and their similarities due to convergence. A revision is long overdue but has been inhibited by the loss of Andrew Smith's important types and the lack of specimens from key areas. Field studies of the Cape forms have begun but it will be some time before sufficient material is collected for a thorough revision. FitzSimons (1943) recognized only two species, with a total of five subspecies. However, current concepts of the genus would include as many as six species, with up to 10–11 subspecies.

*Pseudocordylus microlepidotus microlepidotus* (Cuvier)

Although Loveridge (1944b) listed the range of this large lizard as being restricted to the Cape Peninsula mountains, FitzSimons (1943) knew it to extend as far as Prince Alfred's Pass in the Outeniqua Mountains.

*Pseudocordylus microlepidotus namaquensis* Hewitt

Recorded by FitzSimons (1943) from the widely separated localities of Little Namaqualand and Beaufort West. The status of this subspecies needs investigation.

*Pseudocordylus microlepidotus fasciatus* (A. Smith)

Considered by Smith to be a full species, this race is restricted to the Eastern Cape Province from Graaff-Reinet north to Colesberg and east to Tsomo in the Transkei. Specimens collected recently from the Port Elizabeth-Suurberg region may be referable to *P. algoensis* A. Smith which has usually been considered a synonym of *fasciatus* (FitzSimons, 1943; Loveridge, 1944b).

*Pseudocordylus melanotus subviridis* (A. Smith)

Previously treated as *P. s. subviridis* by FitzSimons (1943), and known from the Katberg and Amatola Mountains in the Eastern Cape Province. The status of *Pseudocordylus* with elongate temporal scales has caused tremendous problems, and FitzSimons (1943), Loveridge (1944b), Broadley (1964) and de Waal (1978) have all held different views. The problem derives from the loss of Smith's types of *melanotus* and *subviridis*, and differing interpretations of Smith's illustrations of these types. As *melanotus* has paragraph preference over *subviridis*, de Waal (1978) has elevated *melanotus* to a full species and treated *subviridis* as a subspecies of it. Northern Cape specimens from near Herschel (Broadley, 1964) may be referable to the nominate race, *P. m. melanotus*. Loveridge (1944b) referred *Pseudocordylus* from the Amatola Mountains to his new species *P. langi*, but this species is restricted to the Natal Drakensberg at Mont-aux-Sources and Cathedral Peak (Broadley, 1964).

*Pseudocordylus capensis capensis* (A. Smith)

This species was transferred to *Pseudocordylus* from *Cordylus* by Loveridge (1944b). Although this species and the closely related *robertsi* (see below) share some characters with *Pseudocordylus* (i.e. the neck is covered with granules instead of scales and the dorsal scales

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lack osteoderms), these may be due to convergence. It is known from the Hottentots Holland Mountains in the western Cape eastwards to Robinson's Pass in the Attaqua Mountains.

Specimens collected recently in the Kammanassieberg share features with this and the following subspecies.

### *Pseudocordylus capensis robertsi* (van Dam)

Although FitzSimons (1943) treated this form as a subspecies of *Cordylus capensis*, Loveridge (1944b) re-elevated it to specific status, whilst transferring it to *Pseudocordylus*. It is not found in sympatry with *capensis* and was previously known only from the Van Rhynsdorp-Klawer District. Specimens from Pakhuis Pass in the Cedarberg are intermediate between *capensis* and *robertsi* and the latter is here treated as only a race of *capensis*, pending a full revision of the genus.

### *Cordylus Laurenti*

Perhaps the most typical lizard of the Cape Province, although in number of species it is surpassed by other genera, notably *Pachydactylus* and *Mabuya*. The genus is basically restricted to southern Africa, although one species reaches as far north as Ethiopia. The taxonomy is chaotic and sorely in need of revision. Six, possibly seven, species occur in the Cape Province.

### *Cordylus giganteus* A. Smith

This species is listed more in hope than in fact. Boulenger (1910) recorded a specimen from Colesberg. However, de Waal (1978) failed to find this species in the southern half of the Orange Free State and its presence in the northern Cape is therefore doubtful. If it did previously exist in the northern Cape and is now extinct, it would be a worthy candidate for reintroduction, as is now being done with the Python (*Python sebae*) in the eastern Cape.

### *Cordylus cataphractus* Boie

A well-defined species that inhabits the Western Cape Province from Little Namaqualand to Matjesfontein.

### *Cordylus coeruleopunctatus* (Methuen and Hewitt)

Another well defined species. It is the morphological antithesis of *cataphractus*, being elongate and finely-scaled. It has many resemblances to *Pseudocordylus capensis* and may be close to the ancestral form that gave rise to the latter radiation. Recorded from the southern slopes of the Attaqua and Outeniqua Mountains, from Mossel Bay to Witelsbos Forestry Station.

### *Cordylus macropholis* (Boulenger)

A small species inhabiting the western Cape coastal belt from Little Namaqualand to near Ysterfontein (McLachlan, 1979a).

### *Cordylus peersi* (Hewitt)

A melanistic form known only from the Little Namaqualand region.

### *Cordylus cordylus cordylus* (Linnaeus)

This species, more than any other in southern Africa, is a taxonomist's nightmare. FitzSimons (1943) recognized five subspecies, whilst Loveridge (1944b) increased this number to nine. The most obvious and pressing problem remains the status of the small, melanistic, rugose *niger*, that occurs on the Cape Peninsula but also at Saldanha Bay and the adjacent Islands. Loveridge (1944b) considered it to be a separate subspecies. However FitzSimons

(1943) treated it as a variety as isolated melanistic individuals occurred throughout the range of *cordylus*. Conservatively, FitzSimons' (1943) views are followed here, although the problem is not settled. Visser (1971) has suggested that *niger* may be a subspecies of *C. peersi*. Such a relationship may be possible, although due to priority *peersi* would become a subspecies of *niger*. The identity of specimens from Van Rhynsdorp, considered by FitzSimons (1943) to be typical *cordylus*, but out of the ranges of any of Loveridge's (1944) races of *cordylus*, may give some insight into the problem. With these provisos, the range of the nominate race is currently considered to extend in a wide belt across the Cape from Robben Island to Kokstad in East Pondoland.

*Cordylus cordylus minor* FitzSimons

As its name implies, a dwarf form, presently known only from the type locality at Matjesfontein. Its relationship to the small rupicolous cordylids of Little and Great Namaqualand (i.e. *lawrenci*, *pustulatus*, *namaquensis* and *campbelli*) and to other similar cordylids recently collected from the Nieuweveldberg and Sneeuwberg remains to be resolved.

*Cordylus lawrenci* (FitzSimons)

A small, rupicolous form that has been treated by Loveridge (1944b) as a race of *cordylus* but which shows affinities to *minor* (see previous discussion). Known only from the type locality (Lekkersing, Little Namaqualand) and from near Port Nolloth (Visser, 1979).

*Cordylus tasmani* (Power)

Although treated by both FitzSimons (1943) and Loveridge (1944b) as a subspecies of *cordylus*, this form probably deserves specific recognition. Known from scattered localities in the eastern Cape around Uitenhage, its full range has still to be determined.

*Cordylus polyzonus polyzonus* (Parker)

A wide ranging form found in a wide variety of colours. The Namibian form, *jordani*, that was treated as a full species by FitzSimons (1943) has been reduced to a subspecies of *polyzonus* by Loveridge (1944b). The nominate race extends in a wide belt across the west, north and central Cape Province from Aliwal North to Port Nolloth. It does not occur south of the Cape Fold Mountains.

## Gerrhosaurinae

Represented by four genera in Africa and two on Madagascar. Three genera occur in the Cape Province.

*Gerrhosaurus* Wiegmann

The genus is very ancient and is the possible ancestor of most of the other cordylids. A fossil lizard from the Lower Miocene of Mfanganu Island, Lake Victoria, Kenya, has been referred to the extant species *G. major* (Estes, 1962). Two species occur in the Cape Province.

*Gerrhosaurus flavigularis* Wiegmann

Recorded from scattered localities throughout the Cape with the exception of the north-western region. The species is monotypic as Broadley (1966) has demonstrated that *G. f. fitzsimonsi* Loveridge from East Africa is not valid.

*Gerrhosaurus typicus* (A. Smith)

A rare species restricted to the western Cape from Ceres and Beaufort West (3122 CD) to Little Namaqualand.

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TABLE 1

*Synopsis of the Lizards of the Cape Province*

Family	Genera	Species	Species and Subspecies	Taxonomic* changes
Gekkonidae	9	28	42	26
Varanidae	1	2	2	2
Chamaeleonidae	2	9	9	7
Agamidae	1	3	3	3
Lacertidae	6	18	22	13
Scincidae	4	28	38	18
Cordylidae	7	20	27	15
Total	30	108	143	84

\*Taxa affected by taxonomic revisions subsequent to FitzSimons (1943)

TABLE 2

*Changes in the Nomenclature of Cape Province Pachydactylus*

FitzSimons, 1943	Loveridge, 1947	Current status
<i>purcelli</i>	<i>purcelli</i>	<i>serval purcelli</i>
<i>microlepis</i>	<i>maculatus</i>	<i>maculatus</i>
<i>austeni</i>	<i>austeni</i>	<i>austeni</i>
<i>latirostris</i>	<i>mariquensis latirostris</i>	<i>mariquensis latirostris</i>
<i>mariquensis mariquensis</i>	<i>mariquensis mariquensis</i>	<i>mariquensis mariquensis</i>
<i>mariquensis macrolepis</i>	<i>mariquensis macrolepis</i>	<i>mariquensis macrolepis</i> (= <i>amoenus</i> ?)
<i>ocellatus</i>	<i>geitje</i>	<i>geitje</i>
<i>amoenus</i>	<i>amoenus</i>	<i>amoenus</i> (?)
<i>monticolus</i>	<i>monticolus</i>	<i>geitje</i> (?)
<i>maculatus maculatus</i>	<i>maculatus</i>	<i>maculatus maculatus</i>
<i>maculatus albomarginatus</i>	<i>maculatus</i>	<i>maculatus oculatus</i>
<i>montanus onscepcensis</i>	<i>serval</i>	<i>serval onscepcensis</i>
<i>weberi weberi</i>	<i>weberi weberi</i>	<i>weberi weberi</i>
<i>weberi gariesensis</i>	<i>weberi gariesensis</i>	<i>weberi weberi</i>
<i>punctatus amoenoides</i>	<i>punctatus amoenoides</i>	<i>punctatus amoenoides</i>
<i>rugosus</i>	<i>rugosus rugosus</i>	<i>rugosus rugosus</i>
<i>mentalis</i>	<i>capensis capensis</i>	<i>mentalis</i> ?
<i>capensis capensis</i>	<i>capensis capensis</i>	<i>capensis capensis</i>
<i>capensis labialis</i>	<i>capensis labialis</i>	<i>labialis</i> ?
<i>capensis formosus</i>	<i>capensis formosus</i>	<i>rugosus formosus</i>
<i>capensis barnardi</i>	<i>capensis barnardi</i>	<i>rugosus barnardi</i>
<i>capensis oculatus</i>	<i>maculatus</i>	<i>maculatus oculatus</i>
<i>namaquensis</i>	<i>namaquensis</i>	<i>namaeen s</i>
<i>bibroni</i>	<i>bibroni bibroni</i>	<i>bibroni</i>
<i>laevigatus</i>	<i>laevigatus laevigatus</i>	<i>laevigatus laevigatus</i>

*Tetradactylus Merrem*

Considered by FitzSimons (1943) to be endemic to southern Africa but now known to reach as far north as Katanga, western and northern Zambia, and south-eastern Tanzania. Three species and five subspecies occur in the Cape Province.

*Tetradactylus seps seps* (Linnaeus)

Occurring in the south-western Cape and extending eastwards as far as Cape St Francis.

*Tetradactylus seps laevicauda* Hewitt

Known from Stutterheim and the Katberg in the north-eastern Cape and extending eastwards through the south-eastern Orange Free State to Natal.

*Tetradactylus tetradactylus tetradactylus* (Lacepede)

Restricted to the montane regions of the south-western Cape from Table Mountain to the Cedarberg and Swartberg.

*Tetradactylus tetradactylus bilineatus* Hewitt

A rare eastern race known only from the type locality at Burghersdorp in the eastern Cape.

*Tetradactylus tetradactylus fitzsimonsi* Hewitt

A similarly poorly known form apparently restricted to the southern Cape Province from George to Port Elizabeth.

*Cordylosaurus Gray*

A monotypic genus of small, beautifully coloured gerrhosaurids, restricted to the western regions of southern Africa. Two species, one with two races, were recognized by FitzSimons (1943), although he noted that the only available type of *subtesselatus* was possibly synonymous with *trivittatus*. More importantly it had priority. He retained the two species, however, even though he was aware that Loveridge (1942) had synonymized them. Even more surprisingly, he still recognized the poorly-defined southern race *C. trivittatus australis* Hewitt (distinguished by a fused interparietal and parietal, and narrow dorsal light bands), although earlier Parker (1936) had shown these characters to be unreliable. Loveridge (1942) recognized only a single, variable species, and this has been subsequently accepted (Mertens, 1955, 1971).

*Cordylosaurus subtesselatus* (A. Smith)

A small (usually less than 150 mm) gerrhosaurid that has a bright blue posterior region (although the type lacks this). Ranging from southern Angola throughout the western regions of Namibia and Little Namaqualand and reaching its southern limit at Matjesfontein in the Cape Province.

## DOUBTFUL RECORDS

In 1913 Hewitt and Power reported on a collection of lizards from the McGregor Museum, Kimberley. Two species listed by them for the Cape are of doubtful occurrence.

*Lygosoma sundevalli sundevalli* (A. Smith)

This small, semi-fossorial skink (for long known by the name *Riopa sundevalli*) has recently been transferred to the large Afro-Asian genus *Lygosoma* (Greer, 1977). It extends in a wide belt across the northern regions of southern Africa, being replaced along the Mozambique flood plain by the large, speckled species, *L. afer* (Broadley, 1966b). The Kyky record given by Hewitt and Power (1913) is based on a dried scrap purchased from a Botswana



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bushman (who considered it a much-prized antidote for snake bite). The specimen may thus have been obtained further north. No confirmed records for the Cape exist, although Broadley (1967b) collected specimens only 20 miles north of the tip of the Kalahari Gemsbok National Park.

### *Cordylus tropidosternum jonesi* (Boulenger)

Listed by Hewitt and Power (1913) as occurring at Kimberley, but having been introduced during the diamond-rush with timber brought to the mining camps. No recent records confirm its continued existence. Broadley (1966a) treated *jonesi* as a southern race of *tropidosternum*.

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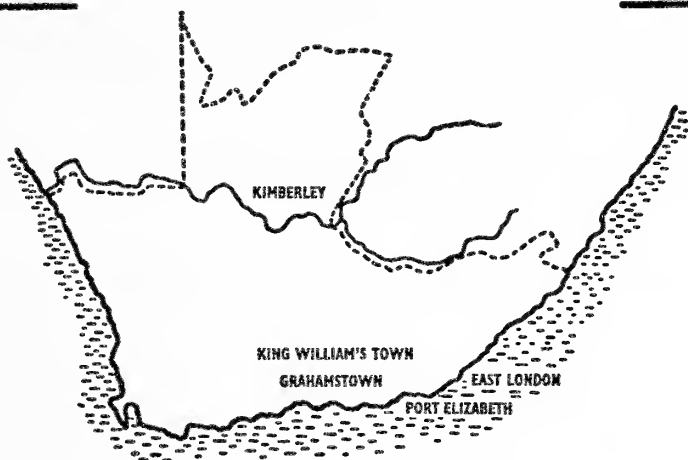


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## **Collections of Recent mammals in southern Africa**

by

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### **INTRODUCTION**

"Systematics collections are complex information acquisition, storage and retrieval systems comprising specimen samples of organisms and associated information about them" (Irwin *et al.*, 1973).

"Systematics collections of plants and animals are the only permanent record of the earth's biota, and the specialized libraries attached to these collections are the written record of the earth's natural history" (National Research Council Committee on research in the life sciences, 1970).

Although the need for general collections from all parts of the world has diminished through the advanced development of traditional mammalogy, the need for improving regional representation in museums continues. The main reason for this is the value of collections as the origin of ideas. Although it is often possible to assemble enough specimens from various museums to address a given problem, it is also true that the problem might not have been obvious in the first place without sufficient material of a taxon in any one museum to indicate that such a problem exists (Zusi, 1969).

Few southern African institutions have Recent mammal collections of sufficient size to carry out an adequate systematic study of any one taxon. This is probably true for most museums the world over in all biological disciplines. Therefore, a very important function of a collection is to make study material available to any *bona fide* research worker.

Collections are scattered worldwide and with the proliferation and growth of collections, locating material which one wishes to study has become a problem. The various mammal collections spread across southern Africa are obviously of great importance to workers on African, and especially on southern African mammals. If such workers do not know of the existence or whereabouts of all the available material of a taxon under review they may be unable to produce conclusive results. This would also be an indirect waste of time and money by both the systematist involved and the institutes which collected the unused material. An example in hand is the revision of the endemic African family Macroscelididae "based on the entire collection of the British Museum, amounting to about a thousand specimens, along with

smaller numbers received on loan or examined in other institutions" (Corbet and Hanks, 1968). By these authors' own admission most species could not be treated adequately at the subspecific level because "distribution and variation" were not better known. Fewer than 80 specimens were examined from collections in Africa, only 11 of these specimens being housed in southern African collections. At the time more than a thousand additional specimens of the family Macroscelididae were available for study in southern African mammal collections.

The authors believe that the present paper will help workers on African mammals by focusing their attention on material which is available in collections from this area.

No previous survey of southern African collections of Recent mammals and their uses has been conducted. Such surveys have regularly been undertaken in North America (Howell, 1923; Douth *et al.*, 1945; Anderson *et al.*, 1963; Choate and Genoways, 1975; Genoways *et al.*, 1976). At present a survey concerning mammal collections of the world is being conducted by Hugh H. Genoways and Duane A. Schlitter. Their survey, however, is not planned to be as extensive as those recently carried out for North America. (Choate and Genoways, 1975; Genoways *et al.*, 1976), or the present study for southern Africa.

The general method of conducting the present survey closely follows that of Choate and Genoways (1975). The authors' objectives were to assess: (1) the size, scope, and location of the systematic resources of mammalogy in southern Africa; (2) the curatorial status of these collections; (3) the actual use of the collection by the systematics community and others; and (4) how to obtain the maximum use out of these collections. They hope the information obtained and presented here will permit the assessment of problems within the discipline, and generate some thought and discussion on how to correct these.

For the purpose of this survey the authors considered southern Africa as the area south of the Cunene—Zambezi rivers, including the following countries: Bophuthatswana, Botswana (formerly Bechuanaland), Lesotho (formerly Basutoland), Moçambique, South Africa, South West Africa/Namibia, Swaziland, Transkei, Venda and Zimbabwe (formerly Rhodesia, Southern Rhodesia).

A questionnaire (Appendix 1) based on that of Choate and Genoways (1975) was drawn up requesting details about the status of collections of Recent mammals as on 1 June 1978. Questionnaires were mailed to: (a) museums; (b) other institutions and private individuals known to have or suspected of having collections of Recent mammals; (c) conservation and wildlife departments; (d) national parks; (e) forestry departments; (f) agricultural departments; and (g) universities. A mailing list was included with each questionnaire and all recipients were requested to inform the authors if they were aware of any additional collections in southern Africa. Notices to this effect were also placed in the *Bulletin of the Southern African Museums Association (SAMAB)*. Further questionnaires were sent in response to answered notices and to notifications of institutions or persons suspected of holding collections.

Subsequently, letters were sent to the curators of the 15 collections reported to have 1 000 or more specimens, requesting the following information: When was the collection started? What was the size of the collection on 1 June 1918, 1 June 1938, 1 June 1958, 1 June 1968, 1 June 1973 and 1 June 1976?

In response to the 121 questionnaires mailed, 91 (75%) replies were received, 41 of which reported collections of over 20 specimens (Table 1). Collections of fewer than 20 specimens were ignored for the purposes of this survey. Based on these replies, the 41 collections of Recent mammals known to exist in southern Africa, held a total of 174 073 specimens on 1 June 1978.

No collections of Recent mammals were reported from the following countries: Bophuthatswana, Botswana (formerly Bechuanaland), Lesotho (formerly Basutoland), Swaziland, Transkei, or Venda. Table 1 summarizes the numbers of collections and specimens housed in the remaining four countries, *viz.*, Moçambique, South Africa, South West Africa/

## COLLECTIONS OF RECENT MAMMALS IN SOUTHERN AFRICA

TABLE 1.—Numbers of Recent mammal specimens and of holotypes and other type specimens in southern African collections (Numbers in brackets refer to collection numbers used in text).

Institution	Total number of specimens	Number of holotypes and other types
National Museum of Rhodesia (37)	67 000	2
Transvaal Museum (30)	28 000	439
Kaffrarian Museum (10)	25 400	30
South African Museum (3)	9 200	13
Queen Victoria Museum (40)	8 030	0
State Museum (36)	7 800	0
S.W.A. Division of Nature Conservation and Tourism— Etosha Ecological Institute (34)	3 689	0
Albany Museum (7)	2 952	4
Natal Museum (22)	2 800	0
University of Rhodesia—Museum of Zoology (41)	2 136	0
Blair Research Laboratory (39)	2 000	0
Cape Provincial Department of Nature & Environmental Conservation—Vrolijkheid (13)	1 800	0
National Museum, Bloemfontein (25)	1 300	0
University of Natal, Pietermaritzburg (24)	1 216	0
Port Elizabeth Museum (12)	1 150	0
Cape Provincial Department of Nature and Environmen- tal Conservation—Jonkershoek (14)	880	0
Universidade Eduardo Mondlane (2)	836	0
University of the Witwatersrand—Bernard Price Institute (28)	700	0
University of Stellenbosch—John R. Ellerman Museum (16)	668	0
Durban Museum (19)	667	0
University of Cape Town (4)	650	0
Orange Free State Division of Nature Conservation (26)	600	0
N. G. Palmer collection (5)	600	0
S.W.A. Division of Nature Conservation and Tourism— Windhoek (35)	593	0
University of Pretoria (31)	478	0
South African Institute for Medical Research, Depart- ment of Epidemiology (27)	350	0
South African National Parks Board—Kruger National Park (32)	350	0
University of Stellenbosch—Department of Forestry (15)	300	0
L. R. Wingate collection (11)	284	0
McGregor Museum (9)	250	0
Natal Parks, Game and Fish Preservation Board— Hluhluwe (21)	241	0
Museu de Historia Natural (1)	208	0

Institution	Total number of specimens	Number of holotypes and other types
Natal Parks, Game and Fish Preservation Board—Pietermaritzburg (23)	200	0
P. B. Fourie collection (29)	180	0
University of Natal, Durban (20)	173	0
Cape Provincial Department of Nature & Environmental Conservation—Rolfontein (18)	132	0
South African Department of Forestry—Saasveld Museum (6)	85	0
W. R. J. Dean collection (33)	60	0
Rhodes University (8)	45	0
Sable Park Museum (38)	40	0
South African National Parks Board—Tsitsikama National Park (17)	30	0

Namibia and Zimbabwe (formerly Rhodesia, Southern Rhodesia). Collections in Moçambique house 0,6 per cent (1 044 specimens) of the known material present in southern Africa, South Africa 47,0 per cent (81 741 specimens), South West Africa/Namibia 6,9 per cent (12 082 specimens), and Zimbabwe 45,5 per cent (79 206 specimens). The size increase since 1918 of 10 of the biggest collections is shown in Table 2.

Ninety-five per cent (164 473 specimens) of this material is housed in 15 collections of 1 000 specimens or more, 69 per cent in three collections of over 20 000 specimens, and 39 per cent in the largest collection (National Museum of Rhodesia). Of the 15 collections holding over 1 000 specimens, four are situated in Zimbabwe, two in South West Africa/Namibia, and the rest in South Africa. Three of these 15 collections (Etosha Ecological Institute, University of Rhodesia, University of Natal at Pietermaritzburg) are essentially teaching collections, and one (Blair Research Laboratory) houses mainly cranial material.

Five collections in southern Africa house all the holotypes and other types (488) known to be present in southern Africa. The majority (90%) of these are held by the Transvaal Museum. Only one publication listing holotypes and other types of mammals has been published in southern Africa (South African Museums' Association, 1958). Holotypes and other types of Recent mammals present in only two southern African museums (Kaffrarian Museum, Transvaal Museum) were listed in this publication. For the Kaffrarian Museum, at least, many mistakes are present, and at the moment a revised and annotated list of holotypes and other types is being drawn up for the Kaffrarian Museum collection.

The Umtali Museum in Zimbabwe, which houses a large herpetological collection, keeps only a small reference collection of mammals, not reported herein, and passes on all other mammal material to the National Museum in Bulawayo. Generally only a relatively small collection of mammals is held at Queen Victoria Museum, apart from material the curator may be studying. The bulk of the Zimbabwean mammal material is deposited in the National Museum.

The East London Museum mammal collection (approximately 1 000 specimens) is now catalogued and housed on permanent loan in the Kaffrarian Museum.

## COLLECTIONS OF RECENT MAMMALS IN SOUTHERN AFRICA

TABLE 2.—Growth of the major collections of Recent mammals in southern Africa over the last 60 years.

Institution	1918	1938	1958	1968	1973	1976	1978
3. South African Museum	3 000	4 000	5 000	6 000	7 000	8 500	9 200
9. Port Elizabeth Museum	212	277	495	623	819	902	1 150
10. Kaffrarian Museum	0	—	18 488	19 406	19 800	25 400	25 400
13. Cape Provincial Department of Nature and Environmental Conservation—Vrolijkheid	0	0	0	0	0	0	1 800
22. Natal Museum	898	1 167	1 292	2 393	2 654	2 734	2 800
26. National Museum, Bloemfontein	0	0	0	0	240	1 000	1 300
30. Transvaal Museum	2 360	8 660	12 600	19 900	—	26 250	28 000
36. State Museum, South West Africa	0	0	0	511	4 149	6 495	7 800
37. National Museum of Rhodesia	250	500	15 000	45 000	55 000	67 000	67 000
39. Blair Research Laboratory	0	0	0	0	0	200	2 000

Part of the material on which the "Check list and atlas of the mammals of Moçambique" (Smithers and Lobão Tello, 1976) was based, is thought to be in Moçambique and housed at either Gorongosa National Park or Maputo (formerly Lourenço Marques). However, the authors were unable to determine the exact whereabouts or size of this collection. Another institution suspected of housing a collection but from which no reply was received is the Department of Zoology, University of the Witwatersrand.

The bulk of the old Medical Ecology Centre collection was deposited in the Transvaal Museum collection in 1971. Only a small reference collection was kept and is now under the auspices of the Department of Epidemiology, South African Institute for Medical Research, Johannesburg.

According to the persons in charge, the following collections will be deposited in reputable museum collections upon completion of the research being done on them: the Cape Provincial Department of Nature and Environmental Conservation collection at Vrolijkheid Nature Conservation Station, and the South West Africa Division of Nature Conservation and Tourism collection in Windhoek.

Between the effective date of this survey (1 June 1978) and the date of publication, four of the smaller collections have been incorporated into larger collections. More than half of the Natal Parks, Game and Fish Preservation Board collection at Pietermaritzburg (c. 120 specimens) was deposited in the Transvaal Museum; the L. R. Wingate collection at King William's Town (284 specimens), the Cape Provincial Department of Nature and Environmental Conservation collection at Jonkershoek, Stellenbosch (880 specimens), and the cranial material from the P. B. Fourie collection at Pretoria (180 specimens) were deposited in the Kaffrarian Museum (total 1 344 specimens).

Electronic data processing is receiving immediate attention in only two collections (John R. Ellerman Museum of Zoology, McGregor Museum).

Two museums, the National Museum of Rhodesia and the Natal Museum have the same acronym (NM). This is an unacceptable situation. The function of an "unique" acronym for a collection is to aid in the identification of specimens belonging to that collection in future studies, particularly with material on loan. It will also be particularly useful in case of a computerized system of information retrieval. The authors suggest that these museums adopt completely new acronyms for their collections, possibly: NMB—National Museum of Rhodesia, and NATM—Natal Museum.

Most of the major collections have their curatorial practices and documentation procedures standardized and many also report having these available in written form. However, few have all procedures available in one document to assist potential collectors, visiting scientists and also the staff in managing the collection in a standardized way. The Kaffrarian Museum has compiled such a document for its collection.

The past and present use of mammal collections and recommendations concerning their maximum utilization will be discussed elsewhere.

### SURVEY OF COLLECTIONS

In the accounts of collections the information is arranged as follows: name (including acronym) and address of collection. Number of specimens; number of holotypes and other types; primary goal of collection (present status of collection and proposed new plans); systematic groups best represented; geographic areas best represented; special preparations; availability of field notes; special files; what percentage of cranial and other skeletal material is cleaned and adequately stored; how specimens are catalogued; significant other collections incorporated into this collection; plans for active development of electronic data processing; professional scientists at the institution (and their main research interests); person directly responsible for the collection; person who completed the questionnaire.

## COLLECTIONS OF RECENT MAMMALS IN SOUTHERN AFRICA

Negative answers are omitted except where these are of particular importance.

The following accounts of reported collections are arranged alphabetically, first by country, then by province (where appropriate), and finally by town or city where the institution or owner is placed.

### MOÇAMBIQUE

**1. MUSEU DE HISTORIA NATURAL (MHN)**, Praça da Travessia do Zambeze, **Maputo** (formerly Lourenço Marques), Moçambique. 208; primary goal is research (the study of mammals only started recently with a Section of Mammals being established within the newly created Department of Natural Sciences); Moçambique; special preparations include 20 elephant foetuses in alcohol, one hippopotamus skeleton, 1 dugong skeleton, 186 mounted specimens; no field notes; special files include 100 colour transparencies of specimens and 30 of habitats, one tape recording; specimens are catalogued by geographical areas, and by collectors; reported by the person responsible—D. J. A. Travassos Santos Dias, Professor of Veterinary Medicine.

**2. UNIVERSIDADE EDUARDO MONDLANE (UEM)**, Faculdade de Biologia, **Maputo** (formerly Lourenço Marques), Moçambique. 836; primary goal is teaching (segregated teaching collection of 23 specimens), also used for research; Rodentia; Gorongosa, Maputo Reserve, Moçambique in general; special preparations include 101 specimens in formalin, 187 skeletons, 493 mounted specimens; field notes; 80 per cent of skulls and other skeletal material are cleaned and adequately stored; specimens are catalogued by systematic groups, by geographic areas, and by collectors; person responsible—Hans Feijen; reported by Augusto Cabral.

### SOUTH AFRICA CAPE PROVINCE

**3. SOUTH AFRICAN MUSEUM (ZM)**, P.O. Box 61, **Cape Town** 8000, Republic of South Africa. 9 200; 13 holotypes and other types; primary goal is research (85%), also used for exhibition, and teaching; Carnivora, Pinnipedia, Bovidae; Cape Province; special preparations include specimens in alcohol, specimens in formalin, skeletons, mounted specimens, specimens of known age, specimens of domestic animals; no field notes; 95 per cent of skulls and other skeletal material are cleaned and adequately stored; specimens are catalogued numerically; scientists at the institution using the collection are Q. B. Hendey (palaeontology), P. Hirschon (archaeology); person responsible—P. Hirschon, Research Assistant; reported by Q. B. Hendey, Curator of Palaeontology, and P. Hirschon.

**4. UNIVERSITY OF CAPE TOWN, DEPARTMENT OF ZOOLOGY (UCTZ)**, Rondebosch, **Cape Town** 7700, Republic of South Africa. 650; primary goal is teaching (80%), also used for research; Rodentia, Carnivora; Cape Flats, De Hoop Nature Reserve, Bontebok National Park, Rooiberg Mountains (Cape Province), Namib Desert (South West Africa/Namibia); special preparations include 20 skeletons, microscope preparations, 60 *Rhabdomys* skulls of known age, more than 400 stomach contents of *Rhabdomys*, skulls and skeletons of domestic animals; field notes; special files include a few colour transparencies of specimens and habitats; 95 per cent of skulls and other skeletal material are cleaned and adequately stored; specimens are not catalogued but recorded by geographic areas; scientists at the institution using the collection are Jennifer U. M. Jarvis (small mammal ecology and physiology), J. H. M. David (rodent ecology); reported by the person responsible—Jennifer U. M. Jarvis, Senior Lecturer.

**5. N. G. PALMER COLLECTION (NGP)**, Private Bag X546, **George** 6530, Republic of South Africa. 600; primary goal is research and reference (at the moment the collection is not

used much since the owner is now involved in estuarine research); Rodentia, Carnivora, Insectivora; Cape Peninsula and vicinity, southern Cape coast, Oviston Nature Reserve, Rolfontein Nature Reserve; special preparations include 450 skulls only; field notes; 90 per cent of skulls and other skeletal material are cleaned and adequately stored; specimens are catalogued numerically; reported by N. G. Palmer, owner.

**6. SOUTH AFRICAN DEPARTMENT OF FORESTRY—SAASVELD MUSEUM (DFSM)**, Saasveld Forest Research Station, Department of Forestry, Private Bag X531, **George** 6530, Republic of South Africa. 85; primary goal is reference collection for ecological studies, used for professional research (90%), and teaching; Rodentia; southern Cape Province; special preparations include 15 specimens in alcohol; field notes; special files include three colour transparencies of specimens, and 50 of habitats; specimens are kept on open shelves; 90 per cent of the skulls are cleaned and adequately stored; specimens are catalogued numerically; scientist at the institution using the collection is G. J. Breytenbach (ecology); reported by the person responsible—G. J. Breytenbach, Professional Officer.

**7. ALBANY MUSEUM (AMM)**, Somerset Street, **Grahamstown** 6140, Republic of South Africa. 2 952; two holotypes and two other types; primary goal is research (but at present used for research, 20%, exhibition, 10% and teaching, 70%—there is a small teaching collection—the vast majority of the mounted specimens and virtually all the records were destroyed in a fire in 1943, no mammal work has been conducted since c. 1940, specimens are at present inadequately stored in boxes, there are plans to reorganize and improve the curatorial condition of the collection in 1980, after which an assessment can be made of the status of the collection and the few remaining records); Chrysochloridae, Viverridae, Muridae; eastern Cape Province; special preparations include 150 specimens in alcohol, 10 skeletons, 50 mounted specimens, many skulls only; few field notes remain after the fire; unknown percentage of skulls and other skeletal material is cleaned and adequately stored; specimens are not catalogued; reported by the person responsible—W. Holleman, Deputy Director.

**8. RHODES UNIVERSITY, DEPARTMENT OF ZOOLOGY (RUZ)**, **Grahamstown** 6140, Republic of South Africa. 45; primary goal is undergraduate teaching (segregated teaching collection), and research; Rodentia; Albany district, Cape Province; special preparations include 20 specimens in formalin, five skeletons; no field notes; most skulls are cleaned, none adequately stored; specimens are catalogued numerically; scientists at the institution using the collection are M. R. Perrin (rodent population biology), T. S. Allen-Rowlandson (kudu biology); reported by the person responsible—M. R. Perrin, Lecturer.

**9. MCGREGOR MUSEUM (MMK)**, P.O. Box 316, **Kimberley** 8300, Republic of South Africa. 250; primary goal is research (to date the collection has mainly been used for teaching—segregated teaching collection of 10 specimens—and exhibition, a research collection of mammals representing the northern Cape Province is planned for the immediate future); Carnivora, Rodentia, Artiodactyla; northern Cape Province; special preparations include specimens in alcohol (46 embryos, mostly springbok), some skeletons, 98 mounted specimens; no field notes; six per cent of skulls and other skeletal material are cleaned and adequately stored; specimens are catalogued numerically; immediate plans for active development of electronic data processing; scientists at the institution using the collection are R. Liversidge (springbok ecology), P. Richardson (scavengers); reported by the person responsible—P. Richardson, Curator of Mammals.

**10. KAFFRARIAN MUSEUM (KM)**, 3 Albert Road, **King William's Town** 5600, Republic of South Africa. 25 400; 30 holotypes and other types; primary goal is research (90%), also used for teaching (segregated teaching collection of 50 specimens), public education, and exhibition; Rodentia, Insectivora, Chiroptera, Lagomorpha, Carnivora; South West Africa/Namibia,



## COLLECTIONS OF RECENT MAMMALS IN SOUTHERN AFRICA

Zambia (formerly Northern Rhodesia), north-western and eastern Cape Province, Malawi (formerly Nyasaland); special preparations include 268 specimens in alcohol, 40 in formalin, 9 skeletons, 30 karyotypic preparations, approximately 300 mounted specimens, a collection of approximately 2 500 skulls, reproductive organs, stomach contents, kidneys, adrenals, eye balls mainly of *Tatera leucogaster* and *Aethomys chrysophilus* preserved in formalin from one locality in the northern Transvaal, South Africa; field notes (in part after Hall, 1962, since January 1978); 70 per cent of skulls and other skeletal material cleaned and adequately stored; specimens are catalogued numerically, and on cards by systematic groups; in 1974 the Kaffrarian Museum bird collection was exchanged for the East London Museum mammal collection (c. 1 000 specimens) which was then incorporated into this collection; scientists at the institution using the collection are Pierre Swanepoel (small mammal systematics), Lloyd R. Wingate (Chiropteran ecology); person responsible—Pierre Swanepoel, Curator of Mammals; reported by Lloyd R. Wingate, Collection Manager, and Pierre Swanepoel.

**11. L. R. WINGATE COLLECTION (LRW)**, 16 Peters Road, **King William's Town** 5600, Republic of South Africa. 284; primary goal is research (these specimens were preserved as voucher specimens for ecological work); Chiroptera; Natal; special preparations include 70 skulls only, 150 specimens in alcohol, 15 specimens of known age; field notes; special files include 100 black and white photographs of specimens, eight of habitats, 80 colour transparencies of specimens, 20 of habitats, 15 minutes of tape recordings; two per cent of cranial and other skeletal material is cleaned and adequately stored; specimens are catalogued numerically; reported by Lloyd R. Wingate, owner.

**12. PORT ELIZABETH MUSEUM (PEM)**, P.O. Box 13147, Humewood, **Port Elizabeth** 6013, Republic of South Africa. 1 150; primary goal is research (95%), also used for teaching and exhibition; Cetacea, Pinnipedia, Rodentia; south-east coast of southern Africa, south-western Indian Ocean, eastern Cape Province; special preparations include specimens in alcohol (e.g. stomach contents), specimens in formalin (e.g. testes), skeletons, microscope preparations; field notes for Cetacea and Pinnipedia; special files include fifteen black and white photographs of specimens, 200 colour transparencies of specimens; all skulls and other skeletal material of marine mammals are cleaned and adequately stored, one per cent of these are degreased, a small proportion of terrestrial mammal skulls and other skeletal material is cleaned and adequately stored; marine mammals are catalogued numerically, cataloguing of terrestrial mammals is pending; scientist at the institution using the collection is G. J. B. Ross (small cetacean biology and systematics); reported by the person responsible—G. J. B. Ross, Curator of Marine Biology.

**13. CAPE PROVINCIAL DEPARTMENT OF NATURE AND ENVIRONMENTAL CONSERVATION—VROLIJKHEID NATURE CONSERVATION STATION (CPA)**, Private Bag 614, **Robertson** 6705, Republic of South Africa. 1 800; primary goal is research (95%), also used for teaching (when work on the collection has been completed, material collected in the different regions of the Cape Province will be deposited in the appropriate regional Cape Provincial Museums, in the meantime the material cannot be obtained on loan); Carnivora; western Cape Province; special preparations include specimens in alcohol, specimens in formalin, specimens of known age (several Carnivora species); field notes; special files include black and white photographs of specimens and habitats, colour transparencies of specimens and habitats; all skulls and other skeletal material are cleaned and adequately stored; specimens are catalogued numerically, and on cards by systematic groups; scientist at the institution using the collection is C. T. Stuart (Carnivora); reported by the person responsible—C. T. Stuart, Research Assistant.

**14. CAPE PROVINCIAL DEPARTMENT OF NATURE AND ENVIRONMENTAL CONSERVATION—JONKERSHOEK NATURE CONSERVATION STATION (JNCS)**, Private Bag 5014, **Stellenbosch** 7600, Republic of South Africa. 880; primary goal is research; Chiroptera; south-western Cape Province; special preparations include all specimens in alcohol; field notes; special files include black and white photographs of specimens, colour transparencies of specimens; some skulls have been removed from fluid-preserved specimens, cleaned and adequately stored; specimens are catalogued numerically; scientist at the institution using the collection is J. C. Herselman (chiropteran ecology and systematics); reported by the person responsible—J. C. Herselman, Research Officer.

**15. UNIVERSITY OF STELLENBOSCH, FACULTY OF FORESTRY (USF)**, **Stellenbosch** 7600, Republic of South Africa. 300; primary goal is teaching; Rodentia, Insectivora; south-western Cape Province; special preparations include 40 specimens in formalin, 10 injected anatomical preparations, some specimens of known age, most specimens skulls only; no field notes; special files include 15 colour transparencies of specimens, 40 of habitats, 10 tape recordings; 40 per cent of skulls and other skeletal material are cleaned and adequately stored; specimens are catalogued numerically; reported by the person responsible—D. Pepler, Technical Assistant.

**16. UNIVERSITY OF STELLENBOSCH—JOHN R. ELLERMAN MUSEUM OF ZOOLOGY (JE)**, **Stellenbosch** 7600, Republic of South Africa. 668; primary goal is research (75%), also used for teaching—segregated teaching collection of 50 specimens (the collection was recently established—1977—and is intended to encourage student research); Rodentia, Insectivora, Carnivora; south-western Cape Province; special preparations include 50 specimens in alcohol, 20 skeletons, 20 injected anatomical preparations, 20 microscope preparations, reproductive organs, embryos, three mounted specimens, 25 specimens of domestic animals; no field notes; special files include 10 black and white photographs of specimens, five of habitats, three colour transparencies of specimens, five of habitats, 15 tape recordings; all skulls and other skeletal material are cleaned and adequately stored; specimens are catalogued numerically, and on cards by systematic groups; electronic data processing utilizing the SELGEM programme package has been initiated; scientists at the institution using the collection are Alan Channing (systematics), staff of the Department of Archaeology (palaeo-ecology); reported by the person responsible—Alan Channing, Curator.

**17. SOUTH AFRICAN NATIONAL PARKS BOARD—TSITSIKAMA FOREST AND COASTAL NATIONAL PARK (TNP)**, P.O. **Storms River** 6308, Republic of South Africa. 30; primary goal is research (90%), also used for exhibition; Tsitsikama (southern Cape Province); special preparations include specimens in alcohol, in formalin, skeletons, mounted specimens; no field notes; special files include a few black and white photographs of specimens, a few colour transparencies of specimens and habitats, one tape recording of otter sounds, two motion pictures; specimens are catalogued numerically; reported by the person responsible—G. A. Robinson, Park Warden.

**18. CAPE PROVINCIAL DEPARTMENT OF NATURE AND ENVIRONMENTAL CONSERVATION—ROLFONTEIN NATURE RESERVE (RNR)**, P.O. Box 23, **Vanderkloofdam** 8771, Republic of South Africa. 132; primary goal is reference and research; Artiodactyla, Carnivora; Rolfontein Nature Reserve (north-eastern Cape Province); special preparations include 13 specimens in formalin, 19 stomach contents in formalin; field notes; skulls and other skeletal material cleaned and adequately stored; specimens are catalogued numerically, and by systematic groups; reported by the person responsible—Ken Coetzee, Senior Nature Conservation Officer.

COLLECTIONS OF RECENT MAMMALS IN SOUTHERN AFRICA

NATAL

**19. DURBAN MUSEUM AND ART GALLERY (DM)**, P.O. Box 4085, **Durban** 4000, Republic of South Africa. 667; the primary goal is research, teaching, and exhibition (but at present used for professional research, 5%, teaching, 60%, public service, 30%, and exhibition, 5%); Chiroptera, Rodentia, Carnivora (*Genetta*); Natal, Cape Province; special preparations include a few bats in alcohol, some mounted specimens; no field notes; skulls and other skeletal material are cleaned and adequately stored; specimens are catalogued numerically; reported by the person responsible—C. Quickelberge, Scientific Officer.

**20. UNIVERSITY OF NATAL—DURBAN, DEPARTMENT OF BIOLOGICAL SCIENCES (UND)**, King George V Avenue, **Durban** 4001, Republic of South Africa. 173; primary goal is teaching, and exhibition; Natal; special preparations include 20 specimens in alcohol, 32 in formalin, 120 skulls only; no field notes; five per cent of skulls and other skeletal material are cleaned and adequately stored; specimens are catalogued by systematic groups; reported by the person responsible—Margaret I. Keogh, Graduate Assistant.

**21. NATAL PARKS, GAME AND FISH PRESERVATION BOARD—HLUHLUWE GAME RESERVE (HGR)**, P.O. Box 25, **Mtubatuba** 3935, Republic of South Africa. 241; primary goal is research (compilation of checklists); Rodentia; Zululand (Natal); special preparations include 187 fluid-preserved specimens, 14 known-age specimens; no field notes; 50 per cent of skulls and other skeletal material are cleaned and adequately stored; specimens are catalogued numerically; scientists at the institution using the collection are P. M. Brooks (general mammalogy), J. L. Anderson (predators); person responsible—P. M. Brooks, Research Officer; reported by P. J. Birkenstock, Research Assistant.

**22. NATAL MUSEUM (NM)**, Loop Street, **Pietermaritzburg** 3201, Republic of South Africa. 2 800; primary goal is research; Rodentia, Insectivora; Natal; field notes; 80 per cent of skulls and other skeletal material are cleaned and adequately stored; specimens catalogued numerically, and on cards by systematic groups; scientist at the institution using the collection is J. A. Pringle (mammals of Natal); reported by the person responsible—J. A. Pringle, Director Emeritus.

**23. NATAL PARKS, GAME AND FISH PRESERVATION BOARD—PIETERMARTIZBURG (DR)**, P.O. Box 662, **Pietermaritzburg** 3200, Republic of South Africa. 200; primary goal is reference; Carnivora, Artiodactyla; Natal Midlands, Natal Drakensberg; special preparations include 35 Artiodactyla skulls only; field notes; scientist at the institution using the collection is D. Rowe-Rowe (small carnivore ecology); reported by the person responsible—D. Rowe-Rowe, Research Officer.

**24. UNIVERSITY OF NATAL—PIETERMARITZBURG, DEPARTMENT OF ZOOLOGY (UNP)**, P.O. Box 375, **Pietermaritzburg** 3200, Republic of South Africa. 1 216; primary goal is teaching (there is a good deal of research material, including karyotypic preparations and voucher specimens in the care of the department from time to time, but these are all eventually deposited in the Transvaal Museum upon completion of research, this temporary material is not included in this account); Artiodactyla, Carnivora, Primates, Rodentia; Natal, southern Africa; special preparations include 10 specimens in alcohol, 30 in formalin, 108 skeletons, five injected anatomical preparations, 30 mounted heads, eight complete skeletons of domestic animals, 1 000 skulls only; no field notes; special files include colour transparencies of specimens and habitats; most skulls and other skeletal material are cleaned but few are adequately stored; specimens are catalogued numerically; reported by the person responsible—J. Meester, Head of the Department of Zoology.

ORANGE FREE STATE

**25. NATIONAL MUSEUM (NMB)**, P.O. Box 266, **Bloemfontein** 9300, Republic of South Africa. 1 300; primary goal is research (93%), also used for teaching and exhibition; Rodentia, Carnivora; Orange Free State; special preparations include 30 specimens in alcohol, five specimens in formalin, 260 skeletons, 1 300 microscope preparations, 20 mounted specimens, five specimens of known age, 15 specimens of domestic animals; field notes; special files include 40 black and white photographs of specimens, 40 colour transparencies of specimens; 90 per cent of skulls and five per cent of skeletons are cleaned and adequately stored; specimens are catalogued numerically, by systematic groups, and by geographic areas; scientist at the institution using the collection is C. D. Lynch (zoogeography, reproduction); reported by the person responsible—C. D. Lynch, Curator of Mammals.

**26. ORANGE FREE STATE PROVINCIAL DIVISION OF NATURE CONSERVATION (ORANVRY)**, P.O. Box 517, **Bloemfontein** 9300, Republic of South Africa. 600; primary goal is research, also used for exhibition; *Lepus capensis*, *Papio ursinus*; Willem Pretorius Game Reserve, and Winburg, Bloemfontein, Brandfort and Theunissen districts (Orange Free State); all specimens are skulls only except for a few used for display; no field notes; skulls and other skeletal material are cleaned but not adequately stored; specimens not catalogued; reported by the person responsible—N. A. Ferreira, Senior Professional Officer.

TRANSVAAL

**27. SOUTH AFRICAN INSTITUTE FOR MEDICAL RESEARCH, DEPARTMENT OF EPIDEMIOLOGY (MEC)**, P.O. Box 1038, **Johannesburg** 2000, Republic of South Africa. 350; primary goals are research, teaching (segregated teaching collection of 20 specimens), and exhibition (in 1971 the bulk of the Medical Ecology Centre, MEC, collection of over 6 000 specimens was donated to the Transvaal Museum and only a reference collection and some extralimital material was kept to assist in disease surveillance, teaching, and exhibition—the Medical Ecology Centre grew from the Plague Research Station of the Department of Health under D. H. S. Davis into the Plague Research Laboratory which was established in 1946 as a joint enterprise with the South African Institute for Medical Research, SAIMR, and still headed by D. H. S. Davis, this became the Medical Ecology Centre in 1957, incorporating all aspects of research into zoonoses with their insect vectors and mammal hosts—from the earliest years D. H. S. Davis built up a comprehensive and valuable collection of small mammals until he retired in 1971—in the late 1960s the State Health Laboratory Sciences took over the Medical Ecology Centre which then became the State Medical Ecology Laboratory and has been stationed in Rietfontein, Pretoria since 1977, although the reference collection has remained at the SAIMR); Rodentia, Carnivora, Primates; southern Africa; special preparations include 50 skins only, 75 specimens formerly from the D. H. S. Davis extralimital rodent collection; field notes; all skulls and other skeletal material are cleaned and adequately stored; specimens are catalogued numerically, by systematic groups, and by geographic areas; scientists at the institution using the collection are Hillary J. Keogh (mammalogy) and some of the entomologists at the SAIMR; reported by the person responsible—Hillary J. Keogh, Mammalogist and Research Officer.

**28. UNIVERSITY OF THE WITWATERSRAND—BERNARD PRICE INSTITUTE FOR PALAEOONTOLOGICAL RESEARCH (BPI-Pal)**, 1 Jan Smuts Avenue, **Johannesburg** 2001, Republic of South Africa. 700; primary goal is research (60%), also used in teaching and public education; Bovidae, Suidae, Hyracoidea, Carnivora, Hystricidae; Karoo (Cape Province), Transvaal, western Kalahari (Cape Province); special preparations include mostly skeletal material, many skulls only, 16 mounted specimens, several known-age specimens,

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several domestic animal specimens, in addition there are 700 bone specimens from cleared porcupine lairs which are catalogued separately from the skeletons; no field notes; special files include black and white photographs of Hystricidae, other specimens, and habitats; all skulls and skeletal material are cleaned and adequately stored; specimens are catalogued numerically, and by systematic groups; scientists at the institution using the collection are Judy M. Maguire (fossil mammals), J. W. Kitching (fossil mammals, reptiles, amphibians), C. E. Gow (early mammals, dinosaurs); reported by the person responsible—Judy M. Maguire, Research Officer.

**29. P. B. FOURIE COLLECTION (PBF)**, Tuberculosis Research Institute, Private Bag X385, **Pretoria** 0001, Republic of South Africa. 180; primary goal is research; *Procapra capensis*; north-eastern Orange Free State; all specimens are skulls only; no field notes; special files include tape recordings (2.5 hours edited), sonograms of 22 different *Procapra capensis* vocalizations; all tape recordings are properly stored in dust free containers; tapes catalogued by date and geographic area, but additionally listing information on systematic group, sex of animal, age, associated behavioural patterns and tape speed (this information exists on the tape itself on the leader section), cranial material not catalogued; reported by P. B. Fourie, owner.

**30. TRANSVAAL MUSEUM (TM)**, P.O. Box 413, **Pretoria** 0001, Republic of South Africa. 28 000; 439 holotypes and other types; primary goal is research (95%), used also for teaching and public education; Rodentia, Insectivora, Chiroptera; South Africa, especially Transvaal Province; special preparations include 250 specimens in alcohol, 200 skeletons 300 karyotypic preparations, 500 mounted specimens, 70 specimens of known age; field notes (since 1970, previously only on occasion); special files include 400 colour transparencies of specimens, 100 of habitats; all skulls and other skeletal material are cleaned and adequately stored; specimens are catalogued numerically, and on cards by systematic groups; the bulk of the South African Department of Health's Medical Ecology Centre collection (MEC) was incorporated into the Transvaal Museum collection in 1971; scientists at the institution using the collection are I. L. Rautenbach and N. J. Dippenaar (mammal systematics), C. K. Brain and E. Vrba (palaeontology), E. Voigt, and I. Plug (archaeology); reported by the person responsible—I. L. Rautenbach, Curator of Mammals.

**31 UNIVERSITY OF PRETORIA, DEPARTMENT OF ZOOLOGY (UPZ)**, **Pretoria** 0002, Republic of South Africa. 478; primary goal is teaching (100%); Rodentia; Transvaal; special preparations include 50 fluid preserved specimens, 130 skeletons, three injected anatomical preparations, several karyotypic preparations, many microscope preparations, three mounted specimens; no field notes; special files include colour transparencies of habitats; five per cent of skulls and other skeletal material are cleaned and adequately stored; specimens are not catalogued; reported by the person responsible—J. A. J. Nel, Professor of Zoology.

**32. SOUTH AFRICAN NATIONAL PARKS BOARD—KRUGER NATIONAL PARK (KNP)**, Private Bag X404, **Skukuza** 1350, Republic of South Africa. 350; primary goal is research (85%), also used for teaching, and exhibition; Chiroptera, Insectivora, Lagomorpha, Rodentia; Kruger National Park (Transvaal), special preparations include specimens in alcohol, in formalin, skeletons, and mounted specimens; no field notes; 50 per cent of skulls and other skeletal material are cleaned and adequately stored; specimens are catalogued by systematic groups; scientists at the institution using the collection are S. C. J. Joubert, U. de V. Pienaar, and G. L. Smuts (zoology), V. de Vos (veterinary ecology); reported by person responsible—S. C. J. Joubert, Chief Research Officer.

**33. W. R. J. DEAN COLLECTION (WRJD)**, P.O. Box 1397, **Tzaneen** 0850, Republic of South Africa. 60; primary goal is as a reference collection to identify prey animals of predatory

birds; Macroscelididae, Soricidae, Chiroptera, Rodentia; northern and western Transvaal; special preparations include 30 skulls only; two skeletons; field notes; all skulls and other skeletal material are cleaned and adequately stored; specimens are catalogued by systematic groups; reported by W. R. J. Dean, owner.

*SOUTH WEST AFRICA/NAMIBIA*

**34. SOUTH WEST AFRICA DIVISION OF NATURE CONSERVATION AND TOURISM—ETOSHA ECOLOGICAL INSTITUTE (EEI)**, Etosha National Park, **Okaukuejo**, South West Africa/Namibia. 3 689; primary goals are research (60%), training of staff, and education of visitors (the purpose of holding study material is to build up a reference collection for local reference and training programmes, additional material is deposited with the State Museum in Windhoek); Insectivora, Chiroptera, Carnivora, Bovidae, Rodentia; Etosha National Park only; special preparations include 25 specimens in alcohol, 25 in formalin, 25 mounted specimens, 3 569 skulls only; no field notes; all skulls and skeletal material are cleaned and adequately stored; specimens are catalogued numerically; scientists at the institution using the collection are John E. W. Dixon (taxonomy, management), H. H. Berry (ecology, behaviour), P. de Villiers (management); person responsible—Senior Conservator (Research); reported by John E. W. Dixon, Principal Nature Conservator.

**35. SOUTH WEST AFRICA DIVISION OF NATURE CONSERVATION AND TOURISM—WINDHOEK (NCTW)**, Private Bag 13186, **Windhoek**, South West Africa/Namibia. 593; primary goal is research (this collection will be deposited in the State Museum, Windhoek on completion of research, only then will it be available on loan); Chiroptera, Gerbillinae (Rodentia); central Namib Desert; special preparations include 160 specimens in alcohol, 240 in formalin, 12 skeletons, one specimen of known age; field notes; special files include 120 colour transparencies of habitats; 12 per cent of skulls and other skeletal material are cleaned and adequately stored; specimens not catalogued; scientist at the institution using the collection is Michael Griffin (small mammal taxonomy, distribution); reported by the person responsible—Michael Griffin.

**36. STATE MUSEUM (SM)**, P.O. Box 1203, **Windhoek**, South West Africa/Namibia. 7 800; primary goal is research (95%), also used for teaching (teaching collection, a few specimens), and public service; Insectivora, Lagomorpha, Rodentia, Carnivora, Hyracoidea; South West Africa/Namibia; special preparations include specimens in alcohol, 100 skeletons, 30 karyotypic preparations, a few mounted specimens, one specimen of known age; field notes; more than 90 per cent of skulls and other skeletal material are cleaned and adequately stored; specimens are catalogued numerically, and on cards by systematic groups; scientist at the institution using the collection is C. G. Coetzee (taxonomy, zoogeography); reported by the person responsible—C. G. Coetzee, Director.

*ZIMBABWE (FORMERLY RHODESIA, SOUTHERN RHODESIA)*

**37. NATIONAL MUSEUM OF RHODESIA (NM)**, P.O. Box 240, **Bulawayo**, Zimbabwe. 67 000; 2 paratypes; primary goal is research (60%), also used for teaching, public service, and exhibition (the main body of mammal collections in the National Museum of Rhodesia is kept here); Rodentia, Insectivora, Carnivora, Lagomorpha, Artiodactyla, Perissodactyla, Hyracoidea; Zimbabwe (formerly Rhodesia, Southern Rhodesia), Zambia (formerly Northern Rhodesia), Botswana (formerly Bechuanaland); special preparations include specimens in alcohol, in formalin, mounted specimens, specimens of known age, a small foetus collection; field notes; 99 per cent of skulls and other skeletal material are cleaned and adequately stored; specimens are catalogued numerically, by systematic groups, and by geographic areas; scien-

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tists at the institution using the collection are K. M. Adams (small mammals, primarily Muroidea), R. J. Peek; reported by person responsible—Curator of Mammals (K. M. Adams till August 1978 and R. J. Peek subsequently).

**38. SABLE PARK MUSEUM (SPM)**, P.O. Box 315, **Que Que**, Zimbabwe. 40; primary goal is to provide an interpretive service (the study centre has only recently been established, it is hoped that research will form the major part of its use, followed by teaching and exhibition); Rodentia; Sable Park; field notes; all skulls and other skeletal material are cleaned and adequately stored; specimens are catalogued by systematic groups; reported by the person responsible—J. M. Stephens, Member of Management Committee.

**39. BLAIR RESEARCH LABORATORY (BRL)**, Ministry of Health, P.O. Box 8105, Causeway, **Salisbury**, Zimbabwe. 2 000; primary goal is research (all skulls and eye-lenses are retained but only definitive collections of study skins are kept); Rodentia; Zimbabwe (formerly Rhodesia, Southern Rhodesia); special preparations include 300 karyotypic preparations, eye-lenses; field notes; special files include five black and white photographs of habitats, colour transparencies of specimens and habitats, tape recordings of ultrasonic sounds, karyotype photomicrographs; all skulls and other skeletal material are cleaned and adequately stored; specimens are catalogued numerically, and on punch cards which can discriminate species, locality, sex, age, ectoparasites; scientists at the institution using the collection are D. H. Gordon and P. Taylor (genetics, ecology, epidemiology, systematics); reported by the person responsible—D. H. Gordon.

**40. QUEEN VICTORIA MUSEUM (QVM)**, P.O. Box 8006, Causeway, **Salisbury**, Zimbabwe. 8 030; primary goal is research (the main body of the mammal collections in Zimbabwe is held at the National Museum, Bulawayo, while only a small collection is held at Queen Victoria Museum in addition to temporary mammal material that is of particular interest to the curator) segregated teaching collection of 30 specimens; Muridae, Carnivora; Zimbabwe (formerly Rhodesia, Southern Rhodesia), Botswana (formerly Bechuanaland), Moçambique; special preparations include 500 specimens in propanol, 100 in formalin, 150 skeletons, 50 injected anatomical preparations, 100 mounted specimens, 15 specimens of known age; field notes; special files include 200 black and white photographs of habitats, 50 colour transparencies of live specimens, 200 of habitats; all skulls and other skeletal material are cleaned and adequately stored; specimens are catalogued numerically, by systematic groups, by geographic areas, and by collectors; small historical collection from C. J. Anderson, 1859; scientist at the institution using the collection is Reay H. N. Smithers (mammalogy); reported by the person responsible—Reay H. N. Smithers, Associate Curator of Mammals (till November 1978).

**41. UNIVERSITY OF RHODESIA—MUSEUM OF ZOOLOGY (URMZ)**, Box MP 167, Mt. Pleasant, **Salisbury**, Zimbabwe. 2 136; primary goal is teaching (95%), also used for exhibition and student research (only 66 per cent of the skin and skull material have their proper skulls, much material has incomplete data, collection has little research value); Rodentia, Microchiroptera; Salisbury district, Kariba Lake area; special preparations include 1 600 specimens in formalin, 42 skeletons, one injected anatomical preparation, microscope preparations, four mounted specimens, five specimens of known age, 36 domestic animals, 236 skulls only; no field notes; special files include electron-microscope photographs of hairs; not all specimens are adequately stored; 75 per cent of skulls and other skeletal material are cleared and adequately stored; specimens are catalogued numerically, and by systematic groups; scientist at the institution using the collection is T. Choate (mammalogy, wildlife management, behaviour, resource ecology); reported by the person responsible—T. Choate, Senior Lecturer.

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# APPENDIX I

## Questionnaire on collections of Recent mammals in southern Africa.

1. What is the formal name (if any), standard abbreviation (if any) and address, of your private or institutional collection?
2. What is the name, address and telephone number of the person directly responsible for the collection?
3. Approximately how many specimens of Recent (not fossil) mammals were in the collection as of 1 June 1978? Approximately how many are not yet catalogued? As of what date?
4. How many holotypes are in the collection? How many other type specimens (syntypes, paratypes, etc.)? As of what date? Has a catalogue or list of these types been published? If so, please give reference.
5. What geographic areas are best represented in the collection?
6. What systematic groups are best represented in the collection?
7. What preparations are represented? Give, if possible, approximate numbers of specimens. Skin and skull? Specimens in alcohol/propanol? Specimens in formalin? Skeletons? Injected anatomical preparations? Karyotype preparations? Microscope preparations? Mounted specimens? Segregated teaching collections? Specimens of known age? Domestic animals? Others (specify)?



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8. Are original field notes and field catalogues routinely conserved with the collection?
9. Are specimens in the collection stored in containers adequate to protect them from damage?
10. Approximately what percentage of skulls and other skeletal material are cleaned and individually enclosed in appropriately labelled containers?
11. What special files are maintained with the collection (if possible, give approximate numbers)? Black and white photographs of specimens? Black and white photographs of habitats? Colour transparencies of specimens? Colour transparencies of habitats? Tape recordings? Motion pictures? Others (specify)?
12. Are specimens recorded in a catalogue arranged: numerically? by systematic groups? by geographic areas? by collectors? others (specify)?
13. Does the collection include specimens referred to in the literature as being in a different collection (for example, a formerly private collection now deposited in an institutional collection)? If so, what collections previously referred to have been combined with yours?
14. Are curatorial practices and documentation procedures standardized for the collection? Are they available in written form?
15. Do you have immediate plans for active development of electronic data processing as a means of assisting collection management and information retrieval?
16. Can specimens be borrowed for study purposes? This presumes that loans are usually made to institutions rather than individuals and that adequate insurance will be carried during shipment; the loan of holotypes is not expected.
17. Approximately how many such loans have been made in the past two years? How many specimens were involved in these loans?
18. Is the collection stored in such a manner as to permit use by visiting scientists? Is someone usually available to aid a scientist who wishes to use the collection? Who should be contacted for such arrangements? Should the arrangement be made in advance?
19. Is a special systematic library maintained near the collection? Do you regard the library as poor? fair? good? excellent? Is use of the library available to persons who might visit the collection?
20. Approximate number of visitors who have utilized the collection in the past two years: professional mammalogists? post-graduate students? other professional scientists? provincial or government employees? others (specify)?
21. In the past two years, how many visiting students have used the collection *directly* in their thesis projects? How many for other projects? How many students have used the collection *indirectly* (such as for deposition of voucher specimens) in their thesis projects? How many for other projects?
22. How is the collection utilized, according to your estimation? Give answer in percentage of total utilization. Professional research? student research? teaching? public service? exhibition? other uses (specify)?
23. What do you regard as the *primary goal* of the collection (e.g. research, teaching, exhibition or others)?
24. Who are the professional scientists at your institution who use the collection, and what are their main research interests?
25. Does your institution produce a periodic or annual report in which information on the collection is routinely reported? If so, give the most recent reference.
26. This questionnaire was completed by: Name, Title, Date.
27. Please add below or on separate sheets, any additional remarks or statistics that may be of interest.

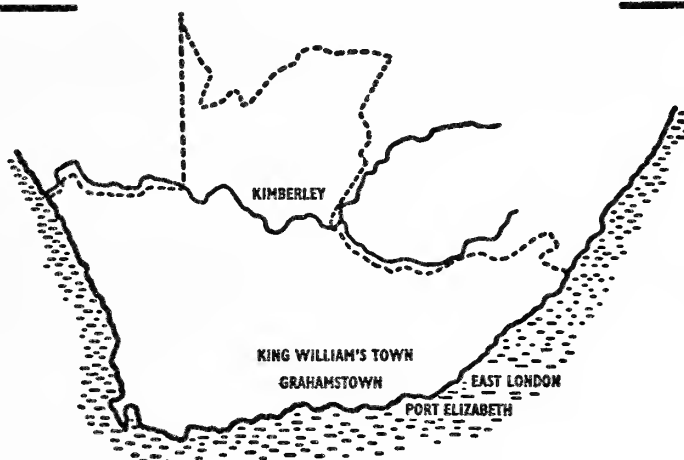


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# ANNALS OF THE CAPE PROVINCIAL MUSEUMS

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**A new species of the whale-louse *Syncyamus* (Crustacea: Amphipoda: Cyamidae) ectoparasitic on dolphins from South Africa**

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**ABSTRACT**

A new species of whale-louse, *Syncyamus aequus* sp. nov., ectoparasitic on the Common dolphin, *Delphinus delphis* Linnaeus, the Blue-white dolphin, *Stenella coeruleoalba* (Meyen), and on *Tursiops aduncus* (Ehrenberg), is described and figured from material collected on the South African coast. The cyamids were taken from the blowhole, snout, mouth, and eye of the hosts, and have the smallest adult body size of any species known to date. The status of *Syncyamus* is reviewed. A table summarizes the sparse literature on cyamid/dolphin associations.

**INTRODUCTION**

In an earlier paper (Lincoln & Hurley 1974a), the authors described a new genus and species of cyamid, *Scutocyamus parvus*, from the common North Atlantic White-beaked dolphin, *Lagenorhynchus albirostris* Gray. With a maximum recorded body size (ovigerous female) of 3.1 mm this was the smallest whale-louse species known at that time. Just completed (Lincoln & Hurley, in press) is an account of a second species of *Scutocyamus*, this time from New Zealand, which has a still smaller body size than *S. parvus*, but in this instance the measurement comes from a non-ovigerous female which may understate the true maximum body size of the species. In the authors' experience the ovigerous specimens are usually slightly larger than the non-ovigerous ones. *Scutocyamus* is especially interesting as one of the few examples of a cyamid that parasitizes the smaller toothed cetaceans, the porpoises and the dolphins (Leung 1967).

A recent collection from the Cape coast of South Africa has now furnished further evidence of cyamids infesting dolphins. The cyamid taken from three different hosts, *Delphinus delphis*, *Stenella coeruleoalba*, and *Tursiops aduncus*, also has a body size smaller than *Scutocyamus parvus*. The largest of the ovigerous females in the collection is only 2.8 mm in length—so small that had it not been for eggs in the brood pouches the authors might have overlooked the specimens as juveniles of an indeterminable species. The cyamids can be referred to the genus *Syncyamus* Bowman, 1955, but represent a hitherto undescribed species. The

name *Syncyamus aequus* sp. nov. is proposed for this species—the specific epithet, taken from the Latin meaning impartial, alluding to the non host-specific habit of this species.

The material was provided by Dr Graham J. B. Ross of the Port Elizabeth Museum and reached the authors in two parts. The first collection came via Professor J. L. Mohr, recently retired from the Department of Zoology at the University of California, Los Angeles. It had been sent to the University by Dr Ross, in the first instance to Dr Yuk-Maan Leung, the foremost of recent workers on cyamids, whose premature death in 1976 was a sad loss from the ranks of amphipodologists. The remainder of the material came to the authors directly from Dr Ross, when the manuscript of the present paper was nearing completion. The authors are grateful to Dr Ross and Professor Mohr for the opportunity to examine this material.

## SYSTEMATICS

Genus *Syncyamus* Bowman, 1955

### DIAGNOSIS

Cyamidae with pereopod 2 larger than 1; antenna 1, 4-articulate; antenna 2, 2-articulate; maxilliped reduced to a simple flap. Unguis not distinct on pereopod 1. Gills simple. Pereon segments 6 and 7 fused. Type species *Syncyamus pseudorca* Bowman, 1955.

The fusion of pereon segments 6 and 7, a key characteristic of this genus, caused some initial confusion. Although apparently fused, there was sufficient indication of a possible suture line to cast doubt on this character until closer examination of prepared specimens using interference phase contrast removed any doubts. The impression of a weak suture line, which is seen with a dissecting microscope under reflected light, may be produced by some subsurface division or the topography of the cuticle.

*Syncyamus aequus* sp. nov.

(Figs 1 a–d, 2 a–c, 3 a–c)

### DESCRIPTION

Length of body from front margin of head to posterior end of pereon in ovigerous female 2.3–2.8 mm, non-ovigerous female 1.6–2.5 mm, male 1.7–2.2 mm; maximum body width on pereon segment 5. No body pigmentation present—all specimens preserved in alcohol. Body narrowly oval in outline with head strongly immersed in pereon segment 2 (pereon segment 1 is fused with the head); anterolateral margins of pereon segment 2 asymmetrically bilobed anteriorly (Fig. 1b). Pereon segments 3–4 subequal in width, little shorter but wider than segment 2 in female, very much shorter and narrower in male; pereon segments 5 and 6 subequal in length and width, pereon segment 7 subtriangular, fused with segment 6, posterior margin weakly sinuous. Ventral pereon surface with 1 pair of short spines on segment 7, 2 pairs on segment 6, and additionally in male only, 1 pair on segment 5. Pleon very small, bilobed. Head sub-rounded; eyes small, oval.

Antenna 1 small, 4-articulate, with articles 2 and 4 much shorter than 1 and 3, apex bearing small group of stout setae. Antenna 2 extremely small, 2-articulate; article 2 much longer than 1, with about 8 stout distal setae. Upper lip fleshy, tending to bilobed (the mouthparts were studied *in situ* using interference phase contrast—the appendages were too fragile to be satisfactorily removed without destroying the specimen); distal surface of upper lip densely fringed with fine setae. Mandibles not easily distinguished, left incisor apparently with 7 teeth, right with 6 teeth. Lower lip inner lobes fused into slender setose plate, outer lobes broad and rounded, setose distally. Maxilla 1 palp short, 1-articulate, about 6 well developed

A NEW SPECIES OF THE WHALE-LOUSE SYNCYAMUS

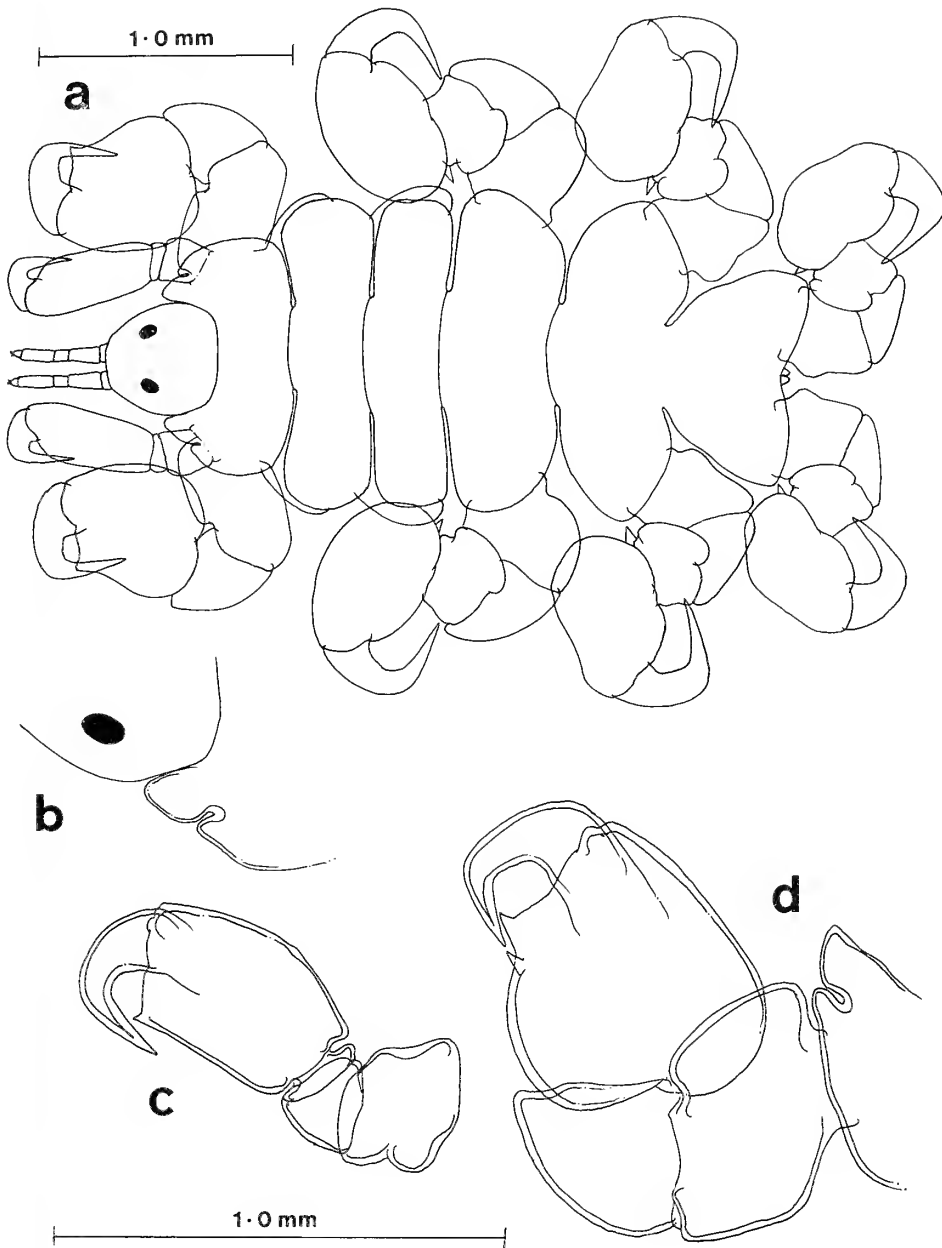


Fig. 1 *Syncyamus aequus* sp. nov. female holotype a, entire dorsal; b, anterolateral angle of first free pereon segment; c, pereopod 1 ventral; d, pereopod 2 ventral. Bar scale 1,0 mm.

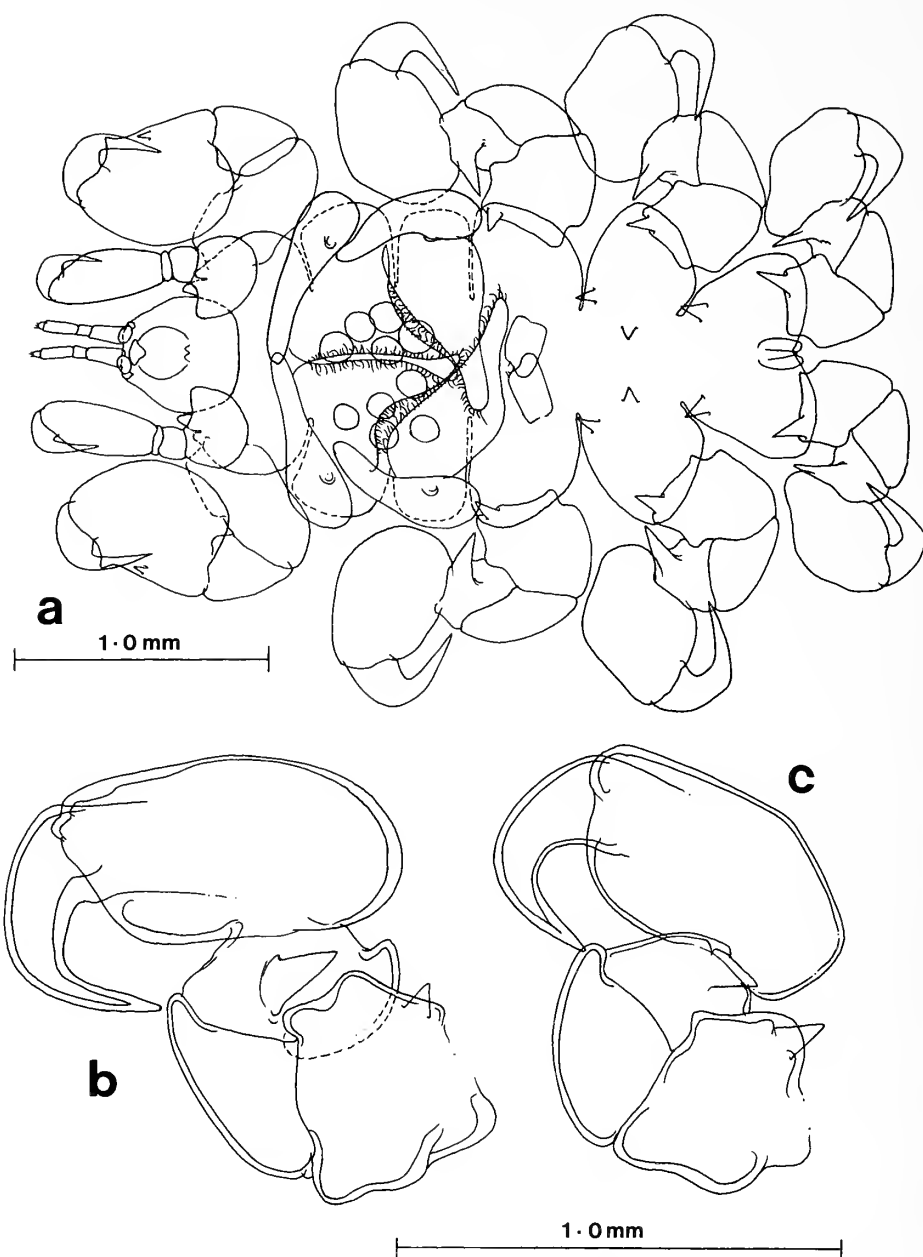


Fig. 2 *Syncyamus aequus* sp. nov. female holotype a, entire ventral; b, pereopod 5 ventral; c, pereopod 7 ventral. Bar scale 1.0 mm.



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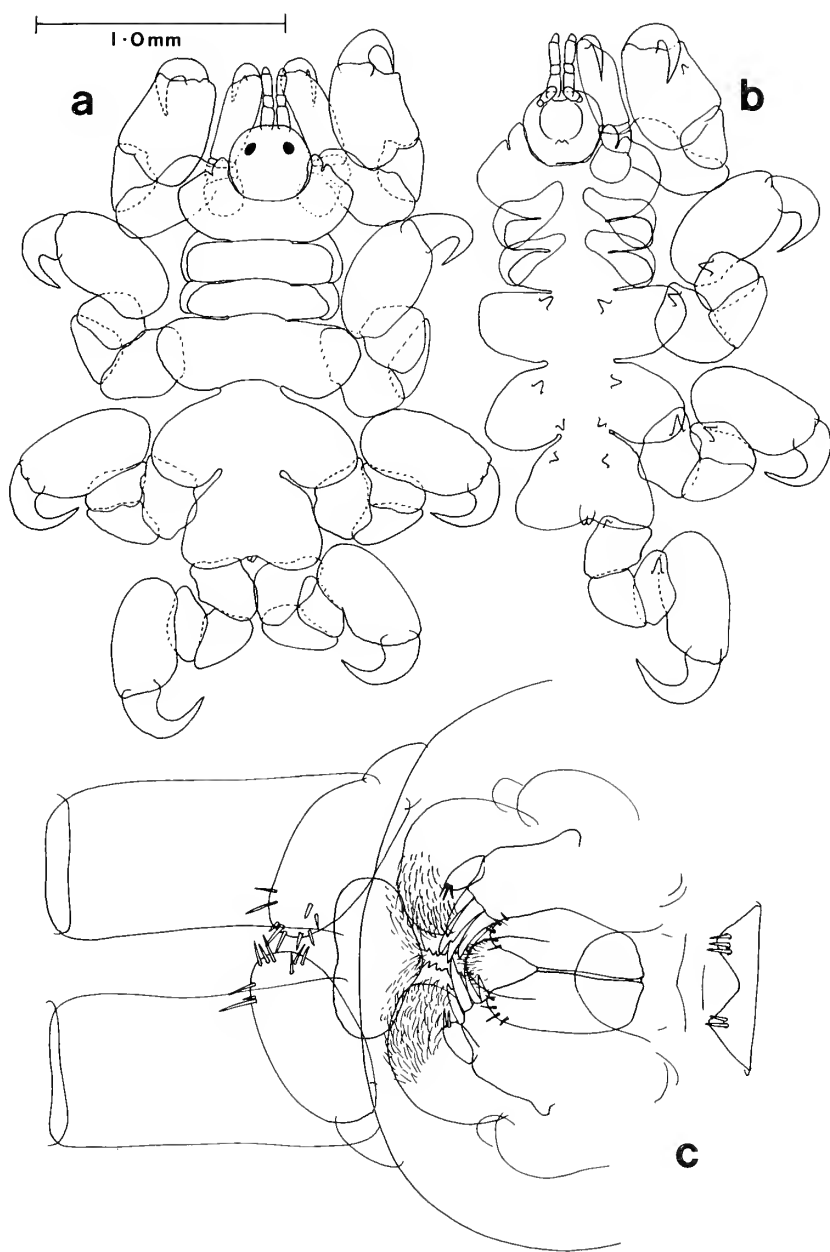


Fig. 3 *Syncyamus aequus* sp. nov. paratypes. a, entire dorsal, male; b, entire ventral, male (right pereopods omitted); bar scale 1,0 mm; c, mouthparts *in situ*, female (high magnification interference phase contrast).

apical teeth on outer plate. Maxilla 2 a single plate, slightly tapering distally with 4–5 stout apical setae; left and right maxillae coalesced along proximal three-quarters of mid-line, only divergent distally. Maxilliped vestigial, formed from small triangular lobes fused into cleft flap, apex of each lobe with 2–3 stout setae.

Pereopod 1 (Fig. 1c) smaller than 2, 5-articulate, propodus subrectangular, palmar margin straight, transverse, delimited by small tooth. Pereopod 2 (Fig. 1d) robust, 4-articulate, propodus slightly longer than wide, anterior and posterior margins strongly convex, palm transverse, delimited by small tooth with accessory tooth on posterior margin close to apex of dactylus. Pereopods 5–7 (Fig. 2b, c) robust, 5-articulate, basal article with large ventral spine on anteroproximal angle, article 3 with very large spine on ventral surface and rounded lobe on inner dorsal surface, propodus oval, palm simple, convex, dactylus strongly curved. Gills short, bluntly rounded apically, directed anteromedially, little shorter in male than female; no accessory gills in male. Brood plates triangular, tapering distally, adjacent margins setose. Holotype female with 10 eggs in brood pouch. Genital valves quadrate.

#### MATERIAL EXAMINED

4 ♀♀, 1 ♂, 2 juv: from *Delphinus delphis*, 1,86 m, male (PEM N 364), 3 miles 110° off East London, South Africa, 26 May 1978, floating dead at sea. Collected from mouth 3 ♀♀ (ovig.), body lengths, 2,7 mm (holotype), 2,8 mm, 2,4 mm; 1 ♀ (non ovig.), 2,2 mm: from axilla 1 ♂, 2,2 mm: from eye 1 juvenile, 1,1 mm: from blowhole 1 juvenile, 1,2 mm. Registration nos. PEM K2a (holotype), PEM K2 b–g (paratypes).

3 ♀♀, 3 ♂♂, 3 juv: from snout and blowhole of *Stenella coeruleoalba*, 2,28 m, female (PEM N 264), Humewood Beach, Port Elizabeth, 26 December 1975. Body lengths; ♀ (ovig.), 2,4 mm; 2 ♀♀ (non ovig.), 2,1 mm, 2,0 mm; 3 ♂♂, 1,7 mm, 1,8 mm, 1,9 mm. Registration no. PEM K7.

1 ♀, 1 ♂, 2 juv: from blowhole of *Stenella coeruleoalba*, 1,96 m, male (PEM N 229), Swartkops River mouth, Algoa Bay, 18 February 1975. Body lengths; ♀, 1,6 mm; ♂, 1,7 mm. Registration no. PEM K8.

1 ♀, 1 ♂: from snout of *Stenella coeruleoalba*, estimated length 2,15 m, male (PEM N 443), Swartkops River mouth, Algoa Bay, 12 March 1980. Body lengths; ♀ (with brood), 2,3 mm; ♂, 1,7 mm. Registration no. PEM K1.

1 ♂, from blowhole of *Tursiops aduncus*, 2,34 m, male (PEM N 358), Salt Rock, Natal, 17 April 1978. Body length 1,9 mm. Registration no. PEM K3.

1 ♂, from blowhole of *Tursiops aduncus*, 1,72 m, immature male (PEM N 331), Natal coast, October 1977. Body length 2,0 mm. Registration no. PEM K4.

2 ♀♀, from blowhole of *Tursiops aduncus*, 2,5 m, male (PEM N 333), Natal shark nets, October 1977. Body lengths, 2,5 mm, 1,8 mm. Registration no. PEM K5.

1 ♂, from blowhole of *Delphinus delphis*, immature (PEM N 320), 1 mile west Cape Recife, Algoa Bay, 10 September 1977. Body length 1,8 mm. Registration no. PEM K6.

The holotype and all paratypes are registered in the collections of the Port Elizabeth Museum, South Africa. One paratype, PEM K2g, has been transferred to the British Museum (Natural History), London.

#### DISCUSSION

This is only the second species of *Syncyamus* named to date, the other being *S. pseudorcae* Bowman found on the False killer whale, *Pseudorca crassidens* (Owen), in the Gulf of Mexico (Bowman 1955). The new species *Syncyamus aequus* is very close to *S. pseudorcae*, but can be distinguished by the detailed morphology of pereopods 1 and 2, by the asymmetry of the anterior lobes of pereon segment 2, and by body size.

# A NEW SPECIES OF THE WHALE-LOUSE SYNCYAMUS

In a subsequent paper, Bowman (1958) identified as *Syncyamus* a collection of small cyamids taken from a dolphin in Panama Bay, although he was uncertain whether they represented a species distinct from *S. pseudorcae*. The largest of these Panama amphipods was an ovigerous female of 3.0 mm body length, considerably smaller than the 4.8 mm female holotype of *S. pseudorcae*, and according to Bowman pereon segments 6 and 7 were not fused. The presence of a suture between segments 6 and 7 should strictly place the material outside the diagnosis of *Syncyamus*, but in the authors' experience this is a rather subjective character as already mentioned for the present material. Where segments are 'relatively fused' and the specimens very small, it can be extremely difficult to resolve precise surface structure using a light microscope. Bowman's Panama material may belong to the species described in this paper—the brief notes available, especially the body size and the reference to the inner anterior lobe of pereon segment 2 being larger than the outer, are consistent with the present description. The dolphin from which the Panama cyamids were collected was tentatively identified for Bowman from a colour photograph as "the long-snouted dolphin, *Stenella graffmani* (Lönnerberg)".

TABLE 1  
*Cyamid/dolphin associations*

HOST	PARASITE
<i>Pseudorca crassidens</i> (Owen) False killer whale	<i>Syncyamus pseudorcae</i> Bowman <i>Isocyamus delphini</i> (Guérin-Méneville)
<i>Phocoenoides truei</i> Andrews True's dolphin	<i>Neocyamus physteris</i> (Pouchet)
<i>Stenella graffmani</i> (Lönnerberg) Gulf of Panama spotted dolphin	<i>Syncyamus</i> sp.
<i>Stenella longirostris</i> (Gray) Long-beaked dolphin	<i>Syncyamus</i> sp.
<i>Stenella coeruleoalba</i> (Meyen) Blue-white dolphin	<i>Syncyamus aequus</i> sp. nov. <i>Syncyamus</i> sp.
<i>Delphinus delphis</i> Linnaeus Common dolphin	<i>Isocyamus delphini</i> (Guérin-Méneville) <i>Syncyamus aequus</i> sp. nov. <i>Syncyamus pseudorcae</i> Bowman <i>Isocyamus delphini</i> (Guérin-Méneville)
<i>Grampus griseus</i> (Cuvier) Risso's dolphin or Grampus	<i>Syncyamus</i> sp.
<i>Tursiops nuuanu</i> Andrews Pacific or Little Bottle-nosed dolphin	<i>Syncyamus</i> sp.
<i>Tursiops aduncus</i> (Ehrenberg) Indian Ocean Bottle-nosed dolphin	<i>Syncyamus aequus</i> sp. nov.
<i>Steno bredanensis</i> (Lesson) Rough-toothed dolphin	<i>Isocyamus delphini</i> (Guérin-Méneville)
<i>Lagenorhynchus albirostris</i> Gray North Atlantic White-beaked dolphin	<i>Scutocyamus parvus</i> Lincoln & Hurley
<i>Cephalorhynchus hectori</i> (Van Beneden) Pied Hector's dolphin	<i>Scutocyamus</i> sp.

The few additional references to *Syncyamus* in recent literature suggest that their association with dolphins deserves further attention. Leung (1967, 1970) gives 4 different hosts and localities for species listed simply as *Syncyamus* sp.; the Long-beaked dolphin, *Stenella longirostris* (Gray), from the Gulf of California, the Common dolphin, *Delphinus delphis* Linnaeus, from Gibraltar, the Pacific Bottle-nosed dolphin, *Tursiops nuuanu* Andrews, from Mexico, and the Blue-white dolphin, *Stenella coeruleoalba* (Meyen), from an area between Hawaii and the Marshall Islands in the Pacific. The latter record is from the same host as that of *Syncyamus aequus* described in this paper. Leung noted a distinct suture line between pereon segments 6 and 7 in the Gibraltar specimen mentioned above. The authors have had the opportunity to examine this specimen and conclude that the posterior segments are in fact fused, or at least relatively so—there is no suture on the cuticle surface, although a line is apparent at low magnification under a dissecting microscope. The concept of fused or coalesced in these small cyamids is open to interpretation and may cause problems in future work on *Syncyamus*. The authors measured the body length of the Gibraltar specimen as 4.1 mm, not 3.8 mm as given by Leung, and in their view this cyamid belongs to Bowman's species, *Syncyamus pseudorcaea*.

A potential third species, or a senior synonym of one of the two existing species, was published by Costa (1866) as *Cyamus chelipes*, from an unidentified dolphin collected in the Bay of Naples. Unfortunately, Costa's description and figures are totally inadequate for comparison with *S. pseudorcaea* and *S. aequus*, except to say that the species probably belongs to the genus *Syncyamus* (Bowman 1958). It may well have been the same as Leung's Gibraltar species which the authors have determined as *S. pseudorcaea*.

In view of Leung's comments on the lack of host specificity in dolphins it is worthwhile bringing the list of cyamid/dolphin associations up-to-date (Table 1). Source references for this tabulation are Bowman (1955, 1958), Leung (1967, 1970), Lincoln & Hurley (1974a, b, present paper, and in press), Mörzer Bruyns (1971).

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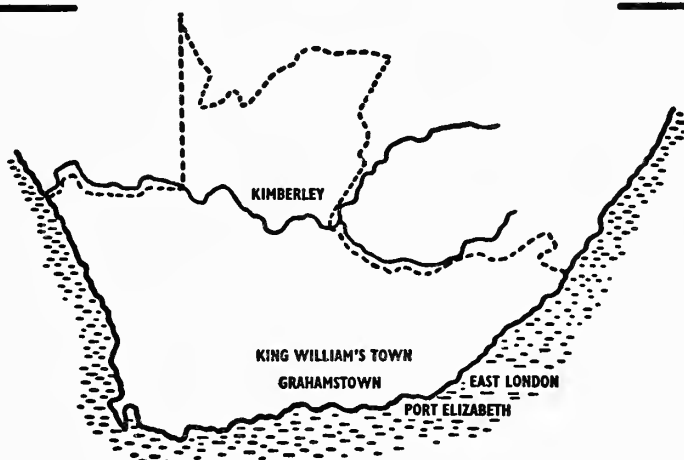


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# A review of the populations of *Kinixys* (Testudinidae) occurring in south-eastern Africa

by

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## ABSTRACT

The populations of hinged tortoises found in Africa south of Latitude 25 °S. and east of Longitude 30 °E. are reviewed. *Kinixys natalensis* Hewitt is reinstated as a full species. The southern material of *K. belliana* Gray appears to represent two subspecies. The large, brightly patterned tortoises with thick-boned convex carapaces are assigned to the typical form (synonym: *K.b. zuluensis* Hewitt), which in this region is restricted to the coastal plain. The smaller, relatively weakly patterned tortoises with thin depressed carapaces are assigned to *K.b. spekii* Gray (synonym: *K. australis* Hewitt), which inhabits the escarpment and plateau areas, but descends onto the coastal plain in southern Moçambique.

## INTRODUCTION

In the last comprehensive revision of the genus *Kinixys*, Loveridge & Williams (1957) recognized a single savanna species with two races: *K. belliana nogueyi* occurring from Cameroun west to Senegal, and the typical form inhabiting a wide range in savannas of the rest of sub-Saharan Africa. They were unaware of the description of *K.b. mertensi* from north-eastern Zaïre by Laurent (1956).

In 1974 Senor J. L. P. L. Tello donated a herpetological collection which included seven *Kinixys* from near Ressano Garcia in southern Moçambique. Five of these specimens were adults of the depressed *spekii* form of *K. belliana*, but another, an adult female, with a worn shell, differed remarkably in proportions and in its relatively small size. Some time later, while

studying Hewitt's 1935 paper, the author was struck by the similarity of the "aberrant" Moçambique tortoise to the old male syntype of *K. natalensis* Hewitt illustrated in Pl. XXXV, Fig. 4. When the author was able to examine the type series of *K. natalensis*, it became apparent that this taxon represents a valid species, sympatric with *K. belliana*. Additional material was examined from Natal, Zululand, Swaziland and southern Moçambique and it was obvious that in this region specimens of *K. belliana* could readily be separated into two subspecies on the basis of carapace height and colour pattern. A relatively clear-cut division between these two taxa can be traced northwards at least to Malawi, so the name *spekii* Gray is revived for the weakly patterned depressed form.

When the author examined the alleged type specimen of *Kinixys belliana* Gray in the British Museum (BM 65.5.3.68: RR 1947.3.5.73), he was surprised to find that it has only four claws on the forefeet and therefore agrees with the West African race *nogueyi*. As Gray's original description states that there are five claws on the feet, it seems clear that this specimen is not the type. It is also smaller (carapace length 170 mm) than the specimen described by Gray in 1831. Further investigation produced another mounted specimen (BM 1979.919) which had recently been removed from display. Scrawled on the plastron in the legend "bought at Humphrey's" and with it is a printed display label recording the fact that the tortoise was presented by Dr J. E. Gray in 1831. It seems clear that this large female (carapace length 191 mm) with five claws on the forefeet is the true type specimen of *Kinixys b. belliana*. It has a shell length/height ratio of 2.10 but the worn shell lacks any pattern.

#### MATERIALS AND METHODS

The present study is restricted to *Kinixys natalensis* and sympatric or parapatric populations of *K. belliana*. The region covered consists therefore of that part of the generic range which lies south of Latitude 25 °S. and east of Longitude 30 °E. The range of *Kinixys* in southern Africa is mapped in Greig & Burdett (1976: Fig. 14).

The most useful diagnostic characters proved to be shape of beak, ratio of shell height/shell length, and carapace pattern. Several ratios used by Laurent (1956; 1962) in his diagnosis of *K. belliana mertensi* were calculated for the southern forms. The measurements were taken with dial calipers. Gular length and width are maximum measurements, but measurements of mid-ventral sulci are average figures in the numerous cases when shield margins are not precisely juxtaposed.

Due to great variability, the only ratio which showed any merit as a diagnostic character was pectoral sulcus/abdominal sulcus. In *K. belliana* there is great variation in the relative lengths of the femoral and anal sulci and this was measured by calculating the ratio femoral sulcus/abdominal sulcus. The shallow gulars of *K. natalensis* were expressed in terms of the ratio gular length/width.

Specimens less than 75 mm in shell length have atypical proportions and were not used in the statistical analyses.

Shell length to the nearest millimetre between blocks (with carapacial hinge closed) was taken as an indication of size, because plastron length is dependent on the very variable development of the gulars. Shell height was also measured between blocks.

The nomenclature of bones and shields follows Zangerl (1969).

Seventy-five specimens were examined from the following institutions (catalogue number prefixes in parentheses): Albany Museum, Grahamstown (AM); British Museum (Natural History), London (BM); Natal Museum, Pietermaritzburg (NM); Transvaal Museum, Pretoria (TM) and Umtali Museum (UM). The collection from the Umtali Museum has been transferred to the National Museum, Bulawayo.

A figure in parentheses after a catalogue number indicates number of specimens in a series.

## CHARACTER ANALYSIS

*Beak*

*K. natalensis* differs from all other species in the genus in having a strongly tricuspid beak which is similar to that found in *Homopus areolatus*. The beak is unicuspid in *K. belliana* (rarely bicuspid in *K.b. nogueyi*: Loveridge & Williams, 1957).

*Ratio shell length/height* (Fig. 1 & Table 1).

The southern material of *K. belliana* can in most cases be allocated to subspecies on the basis of this ratio, i.e. less than 2.3 in *K.b. belliana*, more than 2.3 in *K.b. spekii* (Coefficient

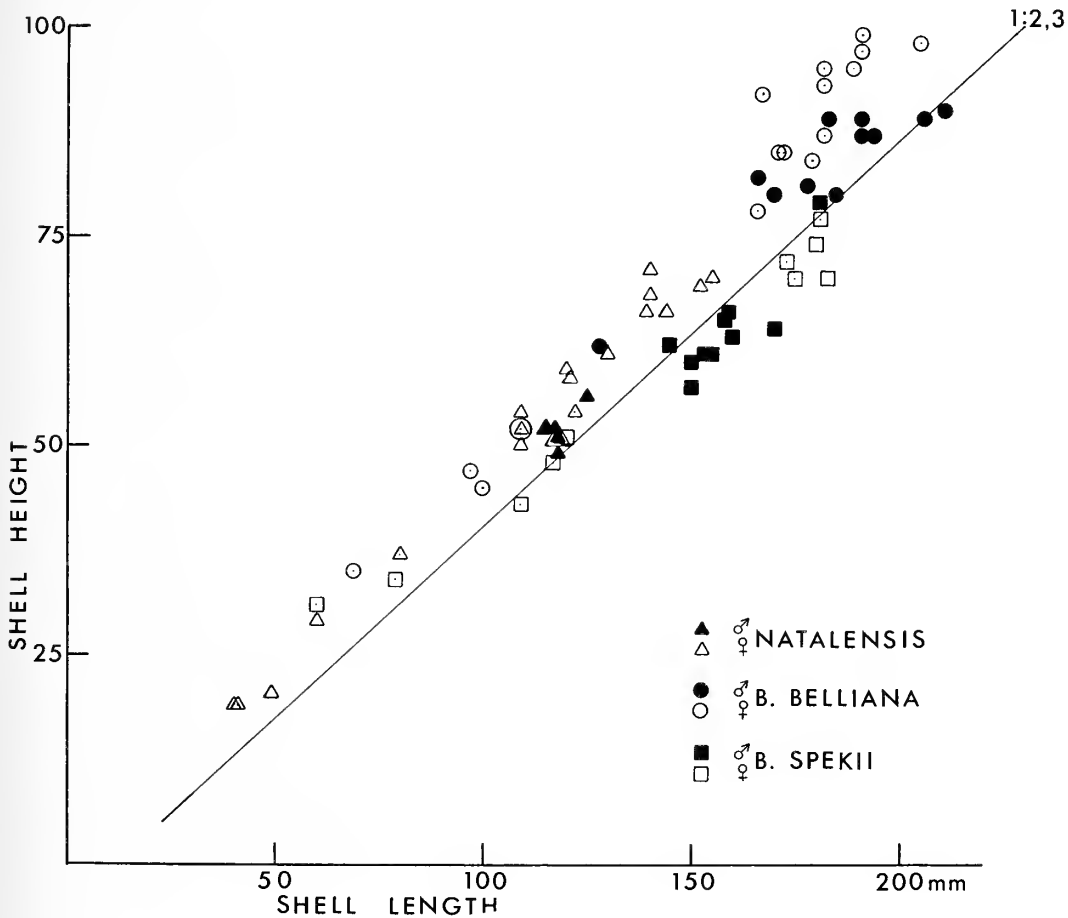


Fig. 1. Scatter diagram showing ratio of shell height: shell length.

of difference = 1,54). Loveridge (1936) found a range of 2,3 to 2,5 in adult *spekii* from northern Tanzania and S.E. Kenya. *K. natalensis* is intermediate in this respect but closer to typical *K. belliana* than to *K.b. spekii*.

TABLE 1.  
*Kinixys* Populations South of Latitude 25 °S.

	N	Range	Mean	S.D.	C.V.	C.D.'s
Shell Length/Height Ratio						
<i>natalensis</i> .....	21	1,97—2,41	2,17	0,11	5,0	N:B = 0,33
<i>b. belliana</i> .....	26	1,82—2,34	2,09	0,13	6,2	N:S = 1,26
<i>b. spekii</i> .....	19	2,29—2,65	2,46	0,12	4,9	B:S = 1,54
Gular Length/Width %						
<i>natalensis</i> .....	21	30,65	43,4	9,8	22,6	N:B = 1,36
<i>b. belliana</i> .....	26	45—81	67,6	8,0	11,8	N:S = 1,07
<i>b. spekii</i> .....	18	45—72	62,3	7,9	12,7	B:S = 0,33
Gular + Humeral Sulcus/Plastron Width at Humero-Pectoral Sulcus %						
<i>natalensis</i> .....	21	55,5—81,1	68,1	7,3	10,7	N:B = 0,31
<i>b. belliana</i> .....	26	60,0—84,9	72,4	6,7	9,3	N:S = 0,18
<i>b. spekii</i> .....	18	58,9—90,6	70,8	8,1	11,3	B:S = 0,11
Pectoral Sulcus/Gular + Humeral Sulci %						
<i>natalensis</i> .....	21	22,5—40,0	31,1	5,2	16,7	N:B = 0,90
<i>b. belliana</i> .....	26	28,6—64,7	45,2	10,4	23,0	N:S = 0,87
<i>b. spekii</i> .....	18	31,8—59,1	42,8	8,3	19,0	B:S = 0,13
Pectoral Sulcus/Abdominal Sulcus %						
<i>natalensis</i> .....	21	18,7—38,2	26,9	5,0	18,6	N:B = 1,21
<i>b. belliana</i> .....	26	31,2—62,9	43,2	8,5	19,7	N:S = 1,07
<i>b. spekii</i> .....	20	25,8—52,0	39,8	7,1	17,9	B:S = 0,22
Femoral Sulcus/Abdominal Sulcus %						
<i>natalensis</i> .....	21	17,5—48,9	32,4	9,7	29,9	N:B = 0,53
<i>b. belliana</i> .....	26	27,8—68,2	42,4	9,0	21,2	N:S = 0,44
<i>b. spekii</i> .....	20	17,4—34,1	26,1	4,6	17,6	B:S = 1,20

#### Thickness of shell.

The southern populations of *K.b. belliana* have a heavy thick-boned shell with deep sulci whereas adjacent populations of *K.b. spekii* have a moderate to thin shell often with a U-shaped fontanelle between the nuchal and the first neural (Fig. 11). A similar fontanelle was noted in the carapace of a *K. belliana nogueyi* from northern Nigeria. The only available skeletal shell of *K. natalensis* is of moderate thickness with no translucent areas.

*Colour pattern.*

In *K. natalensis* the carapacial pattern is basically zonary, with the areolae brown, encircled by zones of orange/yellow and blackish brown, the latter having a ragged or weakly radiate outer margin which tends to break up the peripheral zone of orange/yellow (Fig. 8, left). The shields of the plastron are yellow mesially and along the sulci, these areas being separated by zones of black which are variable in width (Fig. 8, right). The head, limbs and tail are uniformly yellow. There appears to be no sexual dimorphism in colour pattern in this species.

The carapace of *K. belliana belliana* usually has a bold black radial pattern on a yellow ground (Fig. 10). The pattern tends to be more ill defined and broken up in males. The plastron usually has a broad uniformly yellow median zone flanked by an ill-defined radial pattern (Fig. 10, lower right), which may be vestigial or even absent (especially in males).

Males of *K. belliana spekii* are uniformly yellow brown or with darker areolae (*spekii* pattern) or with darker areolae separated by a light zone from a broad dark zone (Fig. 12, upper left). Females are usually more strongly marked than males, having two or three zones of dark weakly radiate markings which may be convergent (Fig. 12, upper right). Plastron markings may be distinct in females (Fig. 12, lower right) but are usually vestigial in males (Fig. 12, lower left).

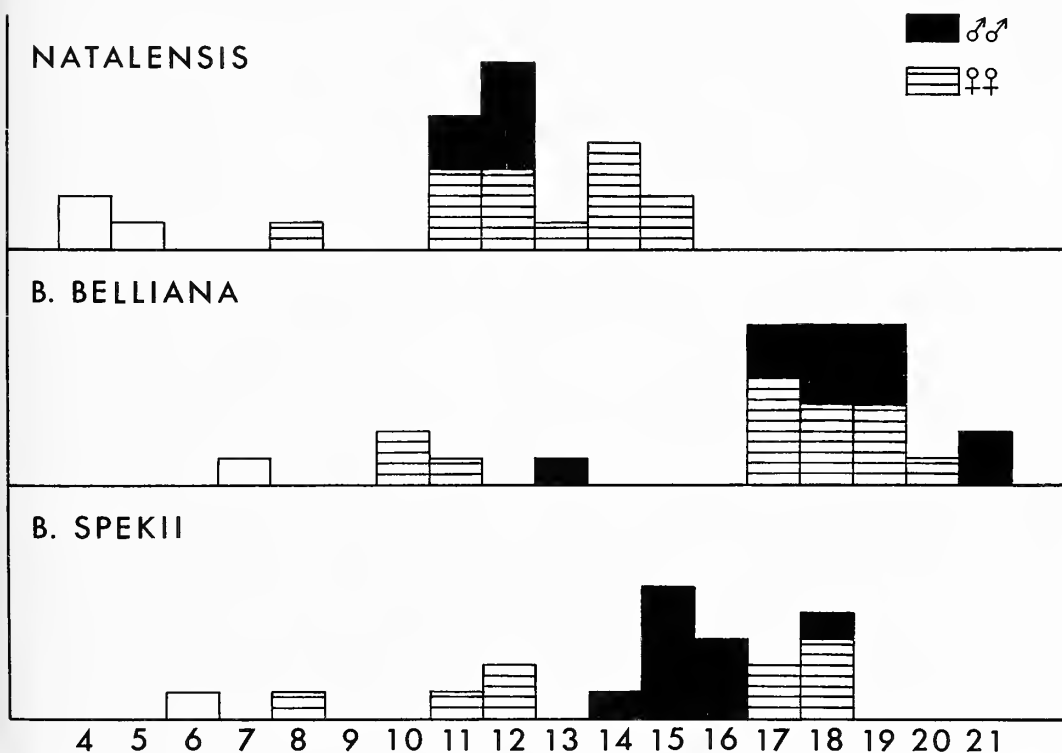


Fig. 2. Histogram to show distribution of specimens by sex in each shell length size class for south-eastern populations of each taxon. The horizontal scale is in centimetres, e.g. class 12 = 116 to 125 mm. The smallest vertical division indicates one specimen.

*Size and sexual dimorphism* (Fig. 2).

Shell lengths for the samples of the three taxa are indicated in Fig. 2. *K. natalensis* is a smaller species than *K. belliana* and the typical form of the latter species attains a larger size than *K.b. spekii*. It should be noted that the seven largest specimens of *K. natalensis* are all females, indicating that there may be sexual dimorphism in size in this species, a phenomenon which is not apparent in *K. belliana*.

*Gular length/width ratio* (Fig. 3 & Table 1).

The scatter diagram shows that most *K. natalensis* have the gulars (together) more than twice as wide as long whereas in *K. belliana* they average approximately one and a half times as wide as long. The Coefficient of Difference between *K. natalensis* and *K.b. belliana* is significant at 1,36 but the C.D. between *K. natalensis* and *K.b. spekii* is only 1,07.

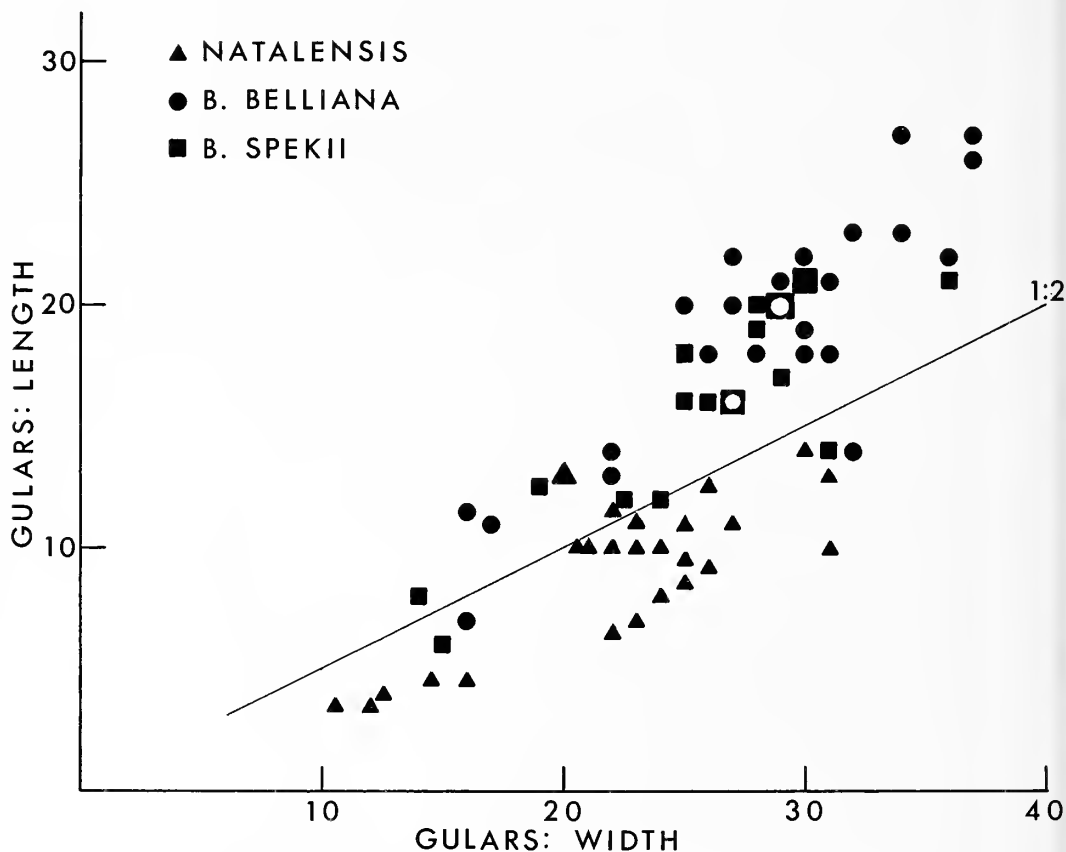


Fig. 3. Scatter diagram showing ratio of gular length: width (of pair).

*Plastron proportions* (Table 1).

Three of the ratios used by Laurent (1956; 1962) in his diagnosis of *K. belliana mertensi* were calculated for the present samples and the data appear in Table 1. These ratios provide

no clear diagnostic characters for the south-eastern populations but *K. natalensis* does have a relatively short pectoral sulcus in relation to the abdominal sulcus (Fig. 4), a ratio used by Wermuth & Mertens (1961) to key out *K.b. mertensi*.

The great variation in the relative lengths of the median anal and femoral sulci in a Beira series of *K.b. belliana* has been mentioned by Boulenger (1907) but a scatter diagram for the south-eastern populations shows a strong tendency for typical *K. belliana* to have the femoral sulcus longer than the anal sulcus whereas in most *K.b. spekii* the situation is reversed (Fig. 5). The variation in *K. natalensis* is nearly as great as in the other two taxa combined.

*The carapacial hinge.*

In *K. natalensis* the hinge is well developed between peripherals seven and eight but even in the largest adults there is hardly any intervention of cartilage between the fourth and fifth costal bones.

In adults of *K.b. belliana* the hinge is very well developed, with the anterior edge of costal five smooth for more than half its length and cartilage often extending round the whole

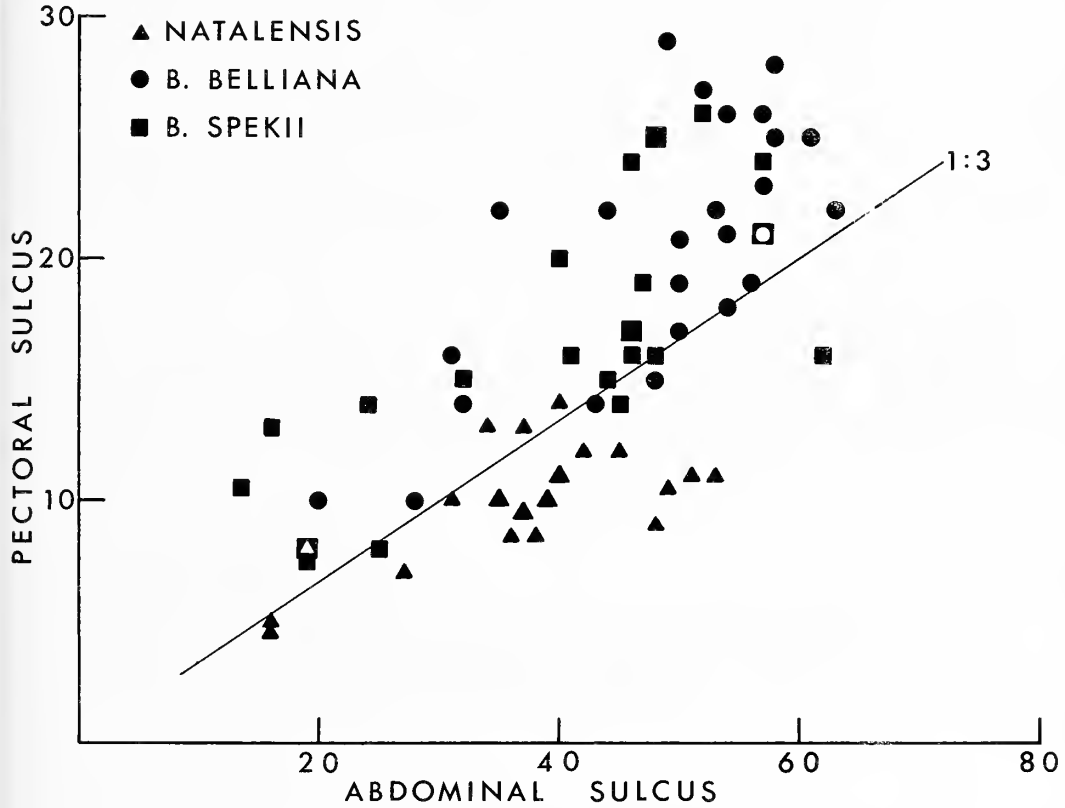


Fig. 4. Scatter diagram showing ratio of pectoral sulcus: abdominal sulcus.

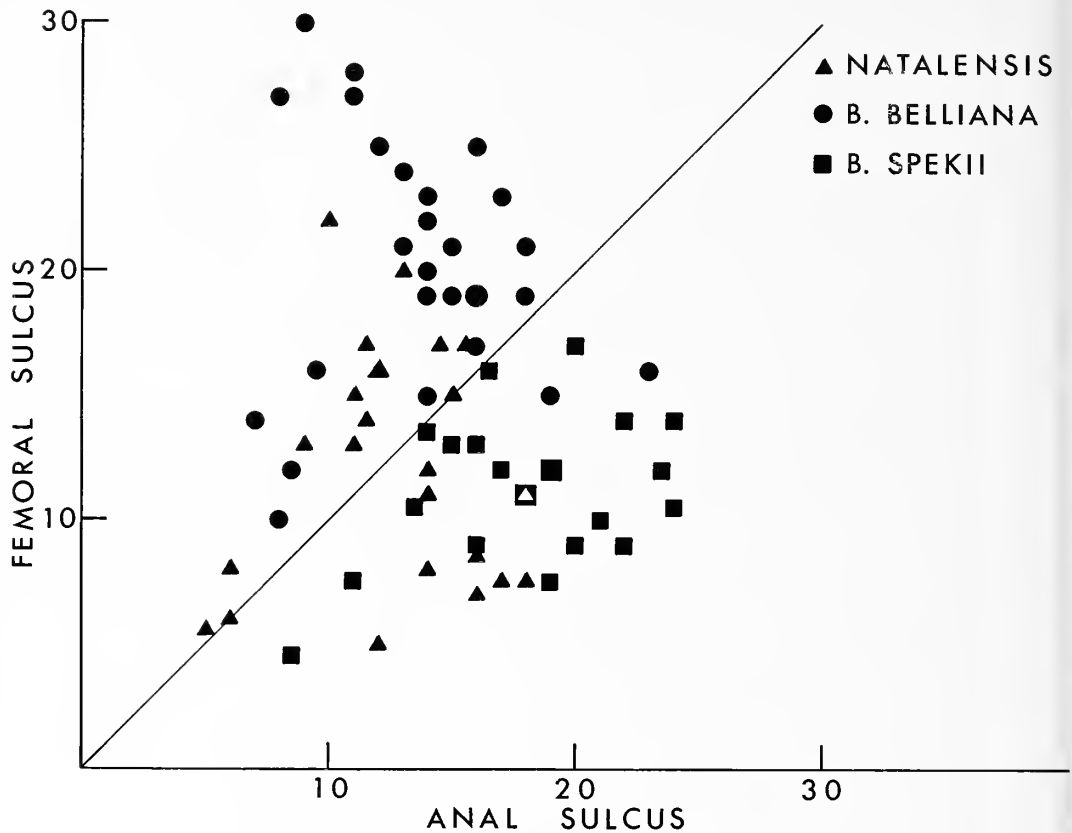


Fig. 5. Scatter diagram showing ratio of femoral sulcus: anal sulcus.

periphery of neural four, although the main hinge runs between neurals four and five. The hinge between vertebral shields three and four lies in a deep gutter which links the upper ends of the fifth costals across the anterior half of neural five.

In *K.b. spekii* the hinge is moderately developed, with cartilage rarely extending more than half-way up the anterior edge of costal five.

*Profile of posterior lobe of carapace.*

The three taxa show marked differences in the profile of the carapace posterior to the hinge. *K. natalensis* often has well developed protuberances beneath the fourth and fifth vertebrals, the shell sloping at about 45° to the peak of the "knob" of the fifth vertebral and then falling away almost perpendicularly to the lower edge of the marginals (Fig. 7), in this respect showing some resemblance to *K. homeana*.



In *K.b. belliana* the carapace curves gradually from the anterior end of vertebral four (Fig. 9) whereas in *K.b. spekii* it slopes very gently to the end of the fourth vertebral and then falls away abruptly from there (Fig. 11).

#### Number of marginals.

*K. belliana* usually has 23 marginals, with 22 or 24 as rare variations due to fusion or division of individual shields. In *K. natalensis* the number of marginals bordering the posterior lobe of the plastron is increased by division of the "supracaudal" (M12) and/or the insertion of extra marginals each side of it. Only five specimens have 23 marginals, fourteen have 24, three have 25 and three have 26.

#### Shape of marginals in juveniles.

In juveniles of *K. natalensis* the marginal shields are slightly serrated but are not comparable with the multiple sharp spines found on the marginals of the forest species *K. erosa* and *K. homeana*. The marginals of *K. belliana* are not serrate.

#### Bones of the carapace.

The usual neural/suprapygal arrangement in *K. belliana* is 8 neurals + 2 suprapygals, the only variations in seven *K.b. belliana* and four *K.b. spekii* checked for this character are in TM 14877 with the eighth neural fused with the first suprapygal, the type of *zuluensis* with an extra half suprapygal wedged between the standard ones, and a male paratype of *K. australis* which has 9 neurals, 3 suprapygals and 9 costals. Six specimens of *K. natalensis* were checked and two of these have 9 neurals; two have 3 suprapygals and one has a single suprapygal; two (including the lectotype female) have 9 pairs of costals, the eighth pair being subdivided.

*K. natalensis* may consistently differ from *K. belliana* in having the sulcus between the first and second vertebrae crossing the second costal bone rather than the first. This appears to be due partly to larger size of the first vertebral shield and partly to the shape of the first costal (Fig. 7). The same condition occurs in some *K. belliana* with nine costals.

A single shell of *K. natalensis* was disarticulated to allow examination of individual bones. The gular lip of this female specimen (AM 77) is narrow, only 14.2% of the plastron length. This ratio in *K. belliana* ranges from 14 to 25%.

The shortening of the plastron in *K. natalensis* is mainly due to a reduction in the length of the hyoplastra.

#### Postorbital bar of skull.

One skull was prepared for each of the south-eastern taxa. Skulls of *K. natalensis* (AM 77—Greytown) and *K.b. belliana* (AM—St Lucia Bay) lack a postorbital bar whereas a slender postorbital bar is present in the *K.b. spekii* skull (AM 78D—White River, E. Tvl.). This character seems to be very variable in *K. belliana*.

### SYSTEMATIC ACCOUNT

#### Key to the savanna species of *Kinixys*

- 1a. Beak tricuspid; gulars (together) usually at least twice as wide as long; marginals usually 24 or more ..... *natalensis* Hewitt
- 1b. Beak unicuspid (rarely bicuspid); gulars (together) usually less than twice as wide as long; marginals usually 23 ..... 2
- 2a. Forelimb always with 4 claws; range northern Cameroun west to Senegal ..... *belliana nogueyi* Lataste
- 2b. Forelimb usually with 5 claws (occasional specimens have 4) ..... 3
- 3a. Median pectoral sulcus short, 0 to 31% of both gular + humeral sulci and abdominal sulcus; range northern Zaire and Uganda ..... *belliana mertensi* Laurent

- 3b. Median pectoral sulcus long, 26 to 69% of gular + humeral sulci and 21–60% of abdominal sulcus ..... 4
- 4a. Carapace distinctly convex, shell height usually included in length less than 2,3 times; carapace pattern radial, black on yellow; range eastern Africa from (?) Somalia south to Zululand ..... *belliana belliana* Gray
- 4b. Carapace distinctly depressed, shell height usually included in length more than 2,3 times; carapace pattern basically zonary, males often unpatterned; range central plateau areas of central and southern Africa ..... *belliana spekii* Gray

*Kinixys natalensis* Hewitt

*Kinixys belliana zuluensis* (part) Hewitt, 1931: 475, Pl. xxxviii, Figs 18–20.

*Kinixys natalensis* Hewitt, 1935: 353, Pl. xxxv, Figs 3–4. Type locality: Jameson Drift, Tugela River, Natal. Archer, 1967: 62 & 1968: 13.

*Kinixys belliana belliana* (part) Loveridge & Williams, 1957: 384; Wermuth & Mertens, 1961: 180 & 1977: 70.

*Diagnosis.*

Beak tricuspid; gulars (together) usually at least twice as wide as long; marginals usually 24 or more, the posterior “supracaudal” usually divided.

*Description.*

Beak tricuspid; prefrontal longitudinally divided; frontal entire; forelimb covered with more or less imbricate scales, some enlarged and pointed, forming on anterior edge a longitudinal series of 7–8 from elbow to outer of five claws; hind foot with four claws.

Carapace moderately convex (shell length/height ratio 1,97 to 2,41), often with flat-topped protuberances on vertebrals four and five, with end of carapace more or less vertical from top of posterior knob; anterior margin not or but slightly expanded; posterior marginals slightly reverted, forming a distinct “gutter”, and feebly serrated in adults (serrated in juveniles); dorsal shields often raised, and with well marked concentric growth annuli; nuchal elongate in adults, often minute externally; vertebrals 5, rarely 6 (four specimens); pleurals 4, rarely 5 (one hatchling; on one side of two specimens); marginals 23–26, usually 24, with the posterior “supracaudal” usually partially or completely divided.

Front lobe of plastron truncate anteriorly, not or but slightly projecting beyond anterior border of carapace; gulars paired, wider than long; pectorals with a rather narrow median sulcus; axillaries small (approx. 3); inguinal large (absent only in AM 6975 G), in contact with or separated from sixth marginal, in contact with femoral; hind lobe short and truncate, with a very shallow posterior notch. Adult males without a distinctly concave plastron.

*Colouration.*

Carapace with a concentric pattern on each shield, the areolae light to dark brown, followed by a broad orange yellow zone, then a blackish zone that may be broken up into short rays, it may extend almost to the margin of the shield or may be followed by another orange/yellow zone. The shields of the plastron have extensive more or less symmetrical blackish figures, but the shields have yellow centres and margins. Two black rings on the abdominal shields are particularly prominent (Fig. 8, right). The colour patterns become broken up and ill defined in large adults.

The old female from near Ressano Garcia (UM 30453) appears to have been uniform brown above and uniform yellow below throughout life.

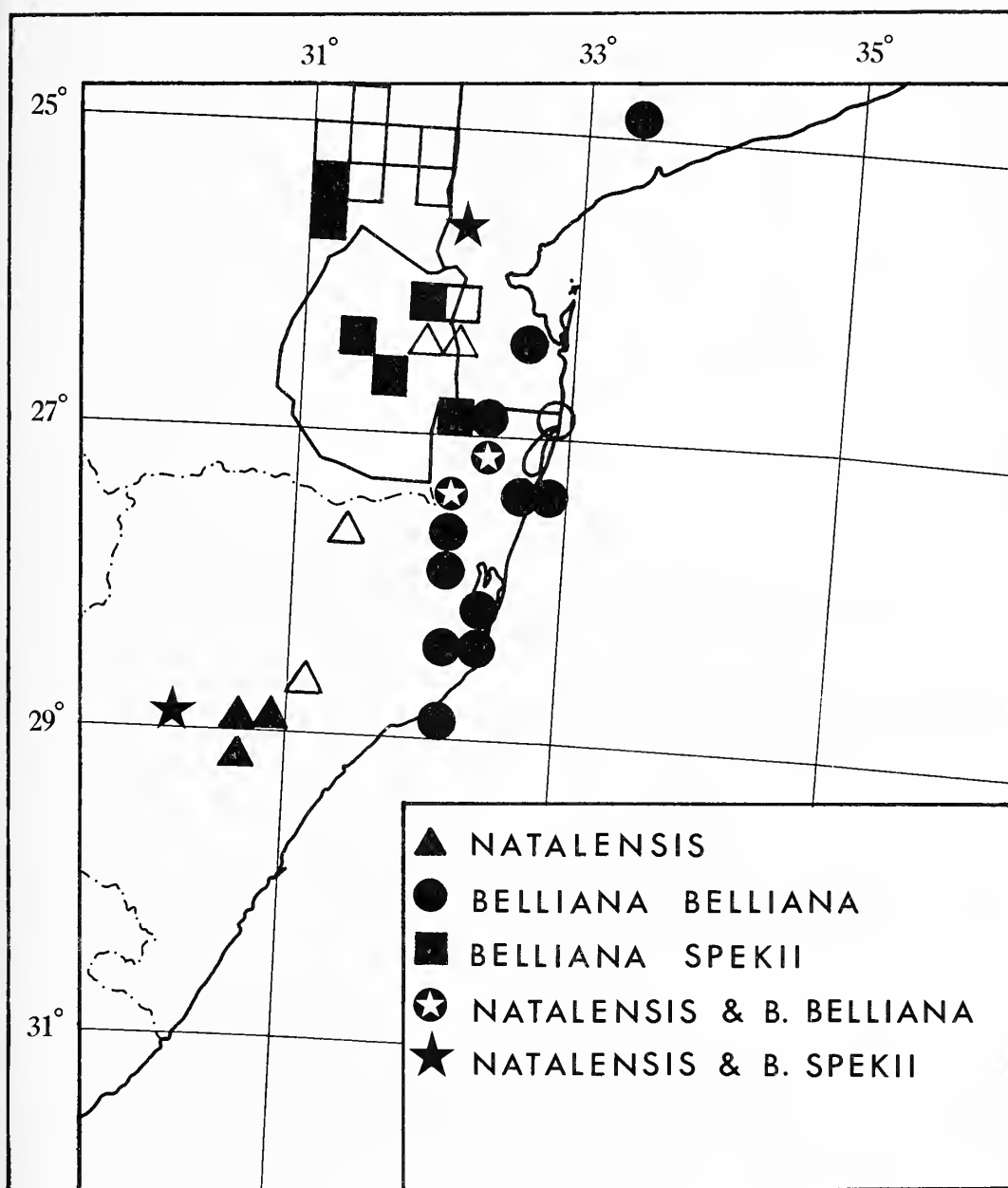


Fig. 6. *Kinixys*: distribution of three taxa south of Latitude 25 °S. and east of Longitude 30 °E. Open symbols denote literature records or specimens identified only from photographs.

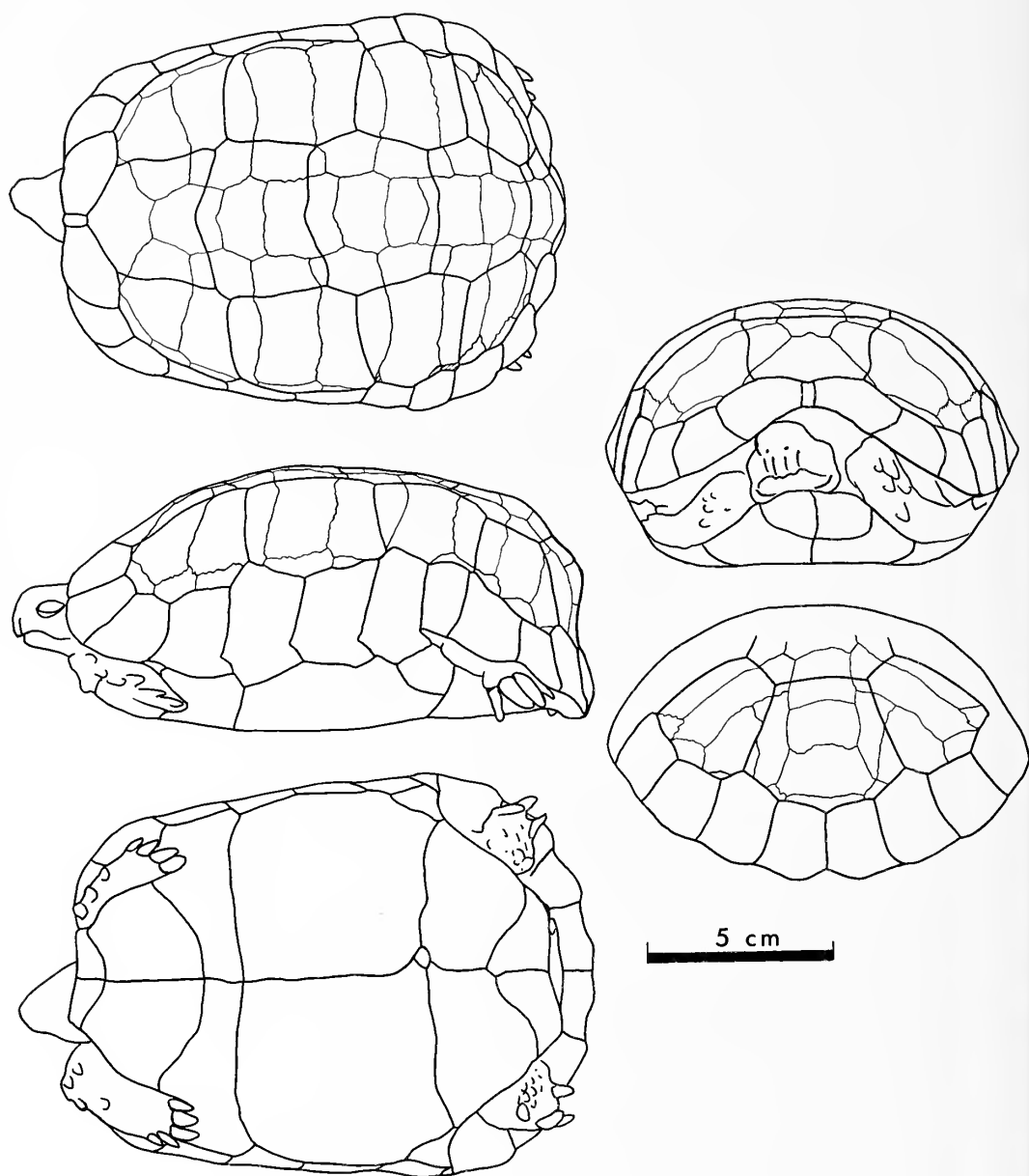


Fig. 7. *Kinixys natalensis*. AM—, Lectotype ♀ from Dimane stream, near Jameson Drift, Tugela Valley, Natal. Dorsal, lateral, ventral, anterior and posterior views. Heavy lines indicate sulci, thin lines indicate sutures between carapacial bones.

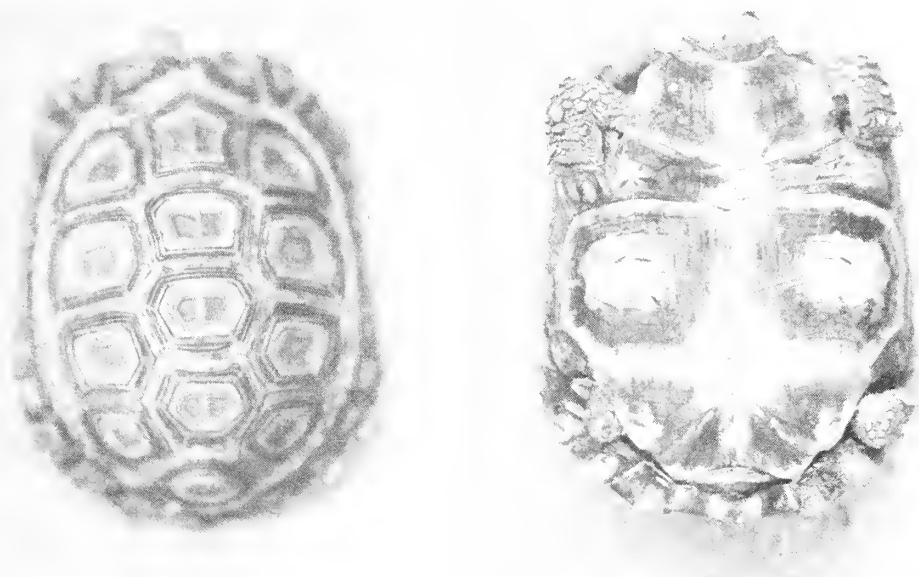


Fig. 8. *Kinixys natalensis* ♀. AM 6975 F—Jameson Drift, Tugela Valley, Natal: dorsal and ventral views.

*Size.*

Largest male (lectoallotype, AM 6975A) 125 mm long, 94 mm wide, 56 mm high; largest female (AM 6975B) 155 mm long, 113 mm wide, 70 mm high.

*Remarks.*

Hewitt (1935) selected and labelled as types an adult male from Jameson Drift (AM 6975A) and an adult female from nearby Dimane Stream (no catalogue number); his type series also included 16 paratypes. The female syntype is here nominated lectotype because it is in better condition and its loose dorsal shields made it possible to remove these and illustrate the arrangement of neural and costal bones in Fig. 7. The lectoallotype male is atypical in having only 23 marginal shields.

*Habitat.*

The type locality was described as “*Euphorbia tirucalli* country, on the rather bare and dry slopes of the Tugela River (altitude 300 m)”. The author has seen a photograph of a female taken in a dry thicket near the summit of the Lebombo Range (550 m) in Swaziland, also photographs of a pair at Itala Nature Reserve in Northern Tall Grassveld/Lowveld ecotone at ca 900 m altitude. A hatchling from Weenen Nature Reserve was in Valley Bushveld at 900 to 1 000 m altitude.

*Distribution.*

The Lebombo Range on the Moçambique-Swaziland border, extending south through western Zululand to Greytown in Natal.

*Localities.*

MOÇAMBIQUE: 10 km SSE of Ressano Garcia UM 30453–4. SWAZILAND: Groenpan Farm (photos: J. Culverwell); Ndzinda Nature Reserve (photo: J. Culverwell). ZULU-

LAND: no precise locality (Hewitt, 1931) NM 1129; Manaba (Hewitt, 1935); Ntambanana (Hewitt, 1931); Otobotini TM 19346. NATAL: Dimane Stream (Hewitt, 1935) AM—(4); Greytown (Hewitt, 1931) AM 77, NM 1130; Impanza (Hewitt, 1931) NM 1143 (2); Itala Nature Reserve (photos: O. Bourquin); Jameson Drift (Hewitt, 1935), AM 6975 (12) BM 1934.10.21.1; Weenen Nature Reserve TM 50682.

*Kinixys belliana belliana* Gray

*Kinixys Belliana* Gray, 1831, Synopsis Reptilium: 69. No locality. Rowe-Rowe, Murray & Daniel, 1968: 53; Bourquin, Vincent & Hitchins, 1971: 21.

*Kinixys belliana* Boulenger, 1905: 252 & 1907: 482.

*Kinixys belliana zuluensis* Hewitt, 1931: 471, Pl. xxxviii, Figs 21–23. Type locality: Richard's Bay, Zululand. Hewitt, 1935: 350, Pl. xxxv, Figs 1–2.

*Kinixys belliana belliana* Loveridge & Williams, 1957: 384 (part). Wermuth & Mertens, 1961: 180 & 1977: 70 (part); Pooley, 1965: 54, Pl. xi.

*Kinixys zuluensis* Archer, 1967: 62 & 1968: 13.

*Diagnosis.*

Beak unicuspid; carapace distinctly convex, shell height usually included in length less than 2.3 times; gulars (together) less than twice as wide as long; marginals usually 23, the posterior 'supracaudal' undivided; colour pattern of carapace radial.

*Description.*

Beak unicuspid; prefrontal entire (but usually with a median cleft anteriorly) or longitudinally divided; frontal large, rarely longitudinally divided; forelimb covered with more or less imbricate scales, some enlarged and pointed, which on anterior edge form a longitudinal series of 8–10 from elbow to outer of five claws (6 claws on right foot of TM 29400); hind foot with four claws.

Carapace moderately convex (shell length/height ratio 1.82 to 2.34), highest point usually on vertebral 3 or 4; vertebrals and pleurals flat or convex with deep sulci; anterior margin often somewhat expanded, not reverted; posterior marginals not or but slightly reverted, not serrated; dorsal shields with well marked growth annuli and deep sulci; nuchal elongate in adults; vertebrals 5; pleurals 4 (5 on left side of type of *K.b. zuluensis* Hewitt); marginals 23 (24 in four specimens, only one due to division of 'supracaudal' M12).

Front lobe of plastron truncate anteriorly, usually projecting beyond anterior border of carapace, especially in males; gulars paired, usually less than twice as broad as long; pectorals with a moderate median sulcus; axillaries 2–3, often very narrow; inguinal large, usually in contact with sixth marginal, in broad contact with femoral; hind lobe short and truncate, with a very shallow posterior notch. Plastron distinctly concave in adult males.

*Colouration.*

Carapace yellow, with a black radial pattern (usually 4–6 rays) on each vertebral and pleural shield. In females the black rays may be largely confluent as in TM 14877 (Hewitt, 1935, Pl. xxxv, Fig. 1), but at the other extreme is TM 13550, with only a few narrow black rays on the vertebrals and pleurals (Hewitt, 1931, Pl. xxxviii, Fig. 22). In males the black pattern is usually less well developed than in females and it is obscure in senile individuals.

The plastral pattern is very variable. In juveniles the plastron is largely black except for a broad median band of yellow extending along the median sulci of the pectorals, abdominals and femorals. Thereafter the black is broken up by yellow intrusions until large adults retain only vestigial black markings, usually in a vaguely radial pattern.

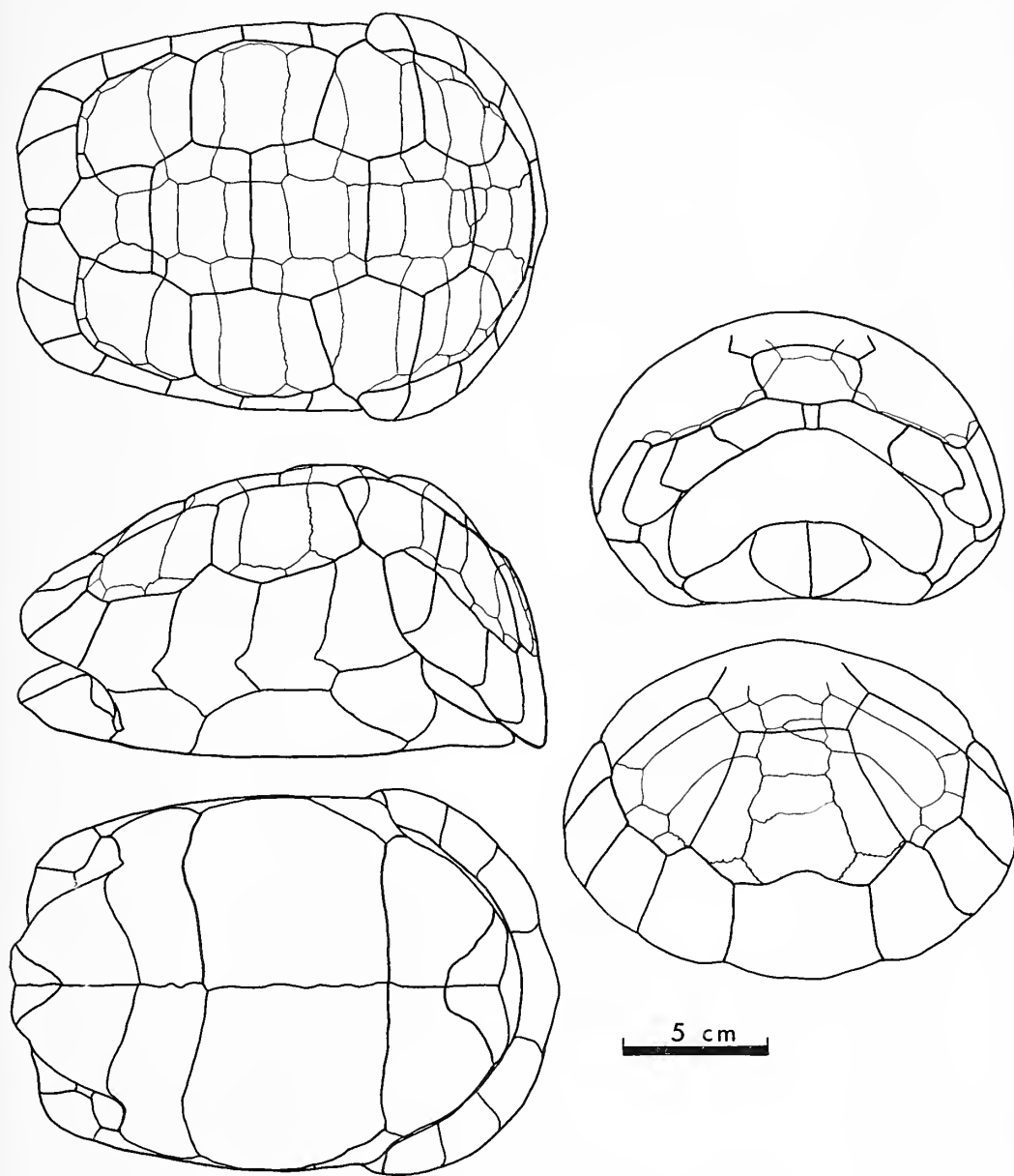


Fig. 9. *Kinixys belliana belliana*. TM 34680, ♀ from Ndumu Game Reserve, Zululand, Dorsal, lateral, ventral, anterior and posterior views. Conventions as in Fig. 8.

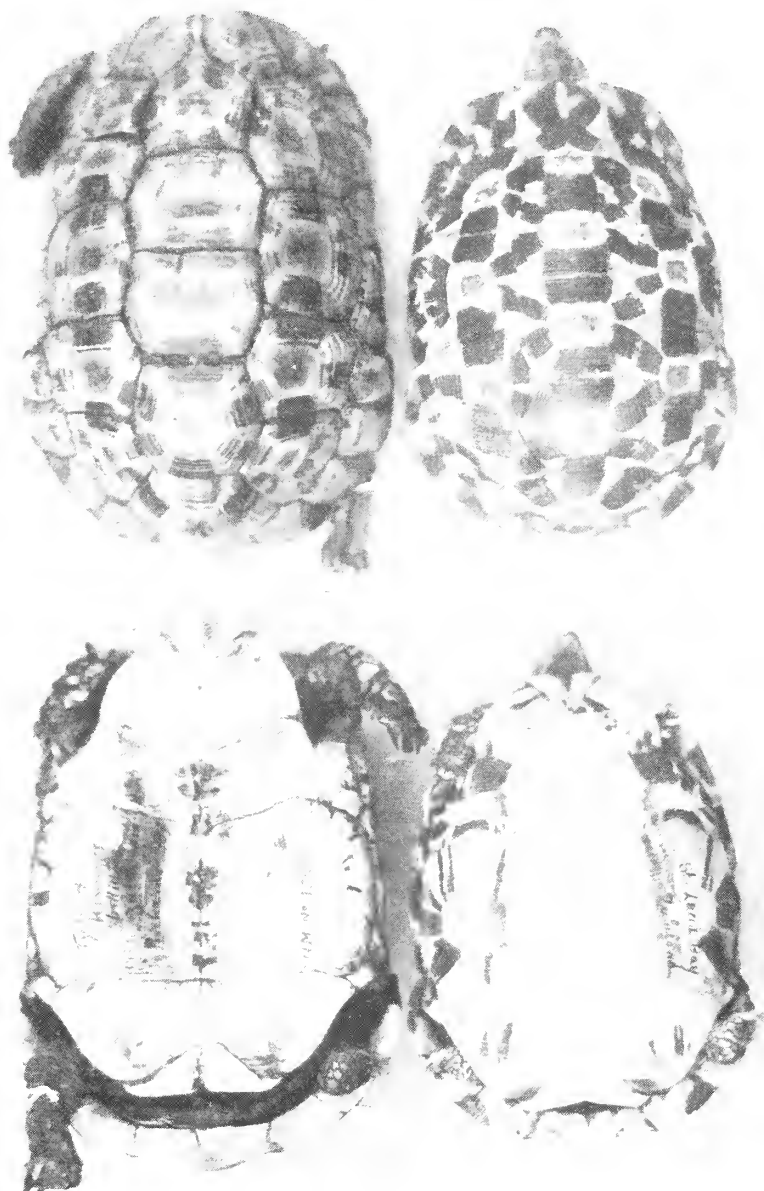


Fig. 10. *Kinixys belliana belliana*. Left ♂ type of *K.b. zuluensis* Hewitt, NM 1203—Richard's Bay, Zululand: dorsal and ventral views. Right, ♀ AM—St Lucia Bay, Zululand: dorsal and ventral views.



The head is yellow, sometimes mottled with grey. The forelimbs are usually mottled yellow and black, the enlarged scales yellow; the hindlimbs and tail are yellow.

*Size.*

Largest male (TM 51378—Candover to Mkuze, Zululand) 211 mm long, 137 mm wide, 90 mm high; largest female (TM 43074—20 km NNW of Hluhluwe, Zululand) 205 mm long, 142 mm wide, 98 mm high.

*Remarks.*

The male type of *K.b. zuluensis* (NM 1203), not illustrated by Hewitt (1931), is shown in Fig. 10 left. It is aberrant in having an extra pleural shield anteriorly on the left side, a supernumerary marginal anteriorly on the right side and the first marginal on the right side is longer than broad, as in *K.b. mertensi* and *K.b. nogueyi*.

*Habitat.*

Hewitt (1935: 355) states that "*zuluensis* seems to belong to the low country of palms, swamps and sand dunes" and in the southern part of its range *K.b. belliana* does appear to be restricted to the coastal plain (classed as Coastal Forest and Thornveld). Haacke (*in litt.*) has a sight record of specimens in coastal dune forest at Mapelane, south of Lake St Lucia. TM 51378 was found on a road through savanna thornveld west of the Lebombo Range.

*Ecology.*

At Lake Sibayi, the faeces of two tortoises contained remains of pill millipedes (Glomeridae), shells of small snails and stones/skins of the fruit *Syzygium cordatum*, the latter fruit also being found in faeces of a tortoise from Kosi Bay (Rowe-Rowe *et al.*, 1968). In St Lucia Park *Kinixys* were seen eating mushrooms with avidity (Rowe-Rowe *et al.*, 1968).

*Distribution.*

East Africa from? Somalia south to Zululand.

*Localities.*

MOÇAMBIQUE: Chimonzo TM 29399–400; Maputo Elephant Reserve TM 41762. ZULULAND: no precise locality AM—(2); Candover to Mkuze TM 51378; Hluhluwe Game Reserve (Bourquin *et al.*, 1971); 20 km NNW of Hluhluwe TM 43074–5; Kosi Bay (Rowe-Rowe *et al.*, 1968); Lake St Lucia (Archer, 1967, 1968; Rowe-Rowe *et al.*, 1968) TM 45828–9; Lake Sibayi (Rowe-Rowe *et al.*, 1968) TM 48265; Lalanek TM 47844; Manaba (Hewitt, 1935) TM 14877; Manzangwenya TM 48729–30; Mtubatuba (Hewitt, 1931, 1935; Archer 1967, 1968) TM 13544, 1549–50; Mkuzi Game Reserve (Pooley, 1965); Ndumu Game Reserve (Pooley, 1965) TM 34678–81; Otobotini TM 19363; Richard's Bay (Hewitt, 1931) NM 1203, type of *K.b. zuluensis*; St Lucia Bay AM—(2); Umfolozi Game Reserve (Archer, 1967, 1968; Bourquin *et al.*, 1971); Umfolozi Station (Boulenger, 1905; Hewitt, 1931, 1935) BM 1905.3.7.66 & 68.

*Kinixys belliana spekii* Gray

*Kinixys spekii* Gray, 1863, *Ann. Mag. nat. Hist.* (3) 12: 381 Central Africa.

*Kinixys australis* Hewitt, 1931: 477, Pl. xxxvi, Figs 4–6. Type locality: White River, Eastern Transvaal.

*Kinixys belliana belliana* Loveridge & Williams, 1957: 384 (part); Wermuth & Mertens, 1961: 180 (part); Pienaar, 1966: 127; Switak, 1971: 9; Wermuth & Mertens, 1977: 70 (part); Pienaar, 1978: 213.

*Kinixys zombensis* (not Hewitt) Archer, 1967: 64 & 1968: 35.

*Diagnosis.*

Beak unicuspid; carapace depressed, shell height usually included in length more than 2.3 times; gulars (together) usually less than twice as wide as long; marginals usually 23, the posterior 'supracaudal' undivided; colour pattern of carapace (if present) zonary.

*Description.*

Beak unicuspid; prefrontal usually longitudinally divided; frontal entire; forelimb covered with more or less imbricate scales, some enlarged and pointed, which on anterior edge form a longitudinal series of 7–10 from elbow to outer of 5 claws; hind foot with 4 claws.

Carapace depressed (shell length/height ratio 2.29 to 2.65), highest point frequently on vertebral 1 or 2; dorsal shields relatively flat, areolae of vertebrae usually with a weak longitudinal keel; anterior margin not or but feebly expanded, not reverted; posterior marginals weakly reverted, not serrated; dorsal shields with well marked growth annuli except in old males, which usually have very worn shells; nuchal moderate to elongate in adults; vertebrae 5 (6 in AM 78D only); pleurals 4 (5 in AM 78D only); marginals 23 (22 in 2; 24 in 2).

Front lobe of plastron truncate anteriorly, projecting well beyond the anterior border of the carapace in both sexes; gulars paired, usually less than twice as broad as long; pectorals with a moderate median sulcus; axillaries two, of moderate size; inguinal large, usually in contact with sixth marginal, in broad contact with femoral; hind lobe short and truncate, with a very shallow posterior notch. Plastron usually concave in adult males.

*Colouration.*

Carapace with a zonary pattern in juveniles and subadults. This may persist in adult males, but they often become uniformly olive-brown or yellow-brown. In females the dark zones tend to break up into ragged radiations. Fig. 12, upper right shows an unusually strongly marked female.

A typical female or juvenile plastral pattern is shown in Fig. 12, lower right. In adult males the plastron is uniformly yellow or may show vestiges of this pattern.

The head, limbs and tail are usually uniformly yellow, but UM 30451 (the strongly marked female shown in Fig. 12, right) has black speckling on the forelimbs.

*Size.*

Largest male (TM 42735—north of Manzini, Swaziland) 181 mm long, 125 mm wide, 77 mm high; largest female (AM 78C—White River, E. Transvaal, lectotype of *K. australis*) 183 mm long, 115 mm wide, 70 mm high.

*Remarks.*

None of the photographs of the type specimens of *K. australis* (Hewitt, 1931: Pl. xxxvi, Figs 4–6) fits any of the White River specimens now in the Albany Museum collection and the plastron of the female does not bear the collector's number "LXXVIII" which appears on all except the smallest of the White River specimens. As Hewitt does not indicate how many specimens he had from White River, it is not known if some were destroyed in the fire at the Albany Museum in 1941, when the early catalogues were destroyed. However, only the large female bears a label inscribed "Type *Kinixys belliana australis* Hwtt" in Hewitt's handwriting and it almost fits the measurements provided by Hewitt, so it is here nominated lectotype. The paratype series consists of two adult males, two small females and a 60 mm juvenile with a separate catalogue number (AM 1295).

*Habitat.*

The area occupied by this taxon south of Latitude 25 °S. is mostly classified as Tropical Lowveld, but the southernmost locality is Weenen in the (Karroid) Valley Bushveld.

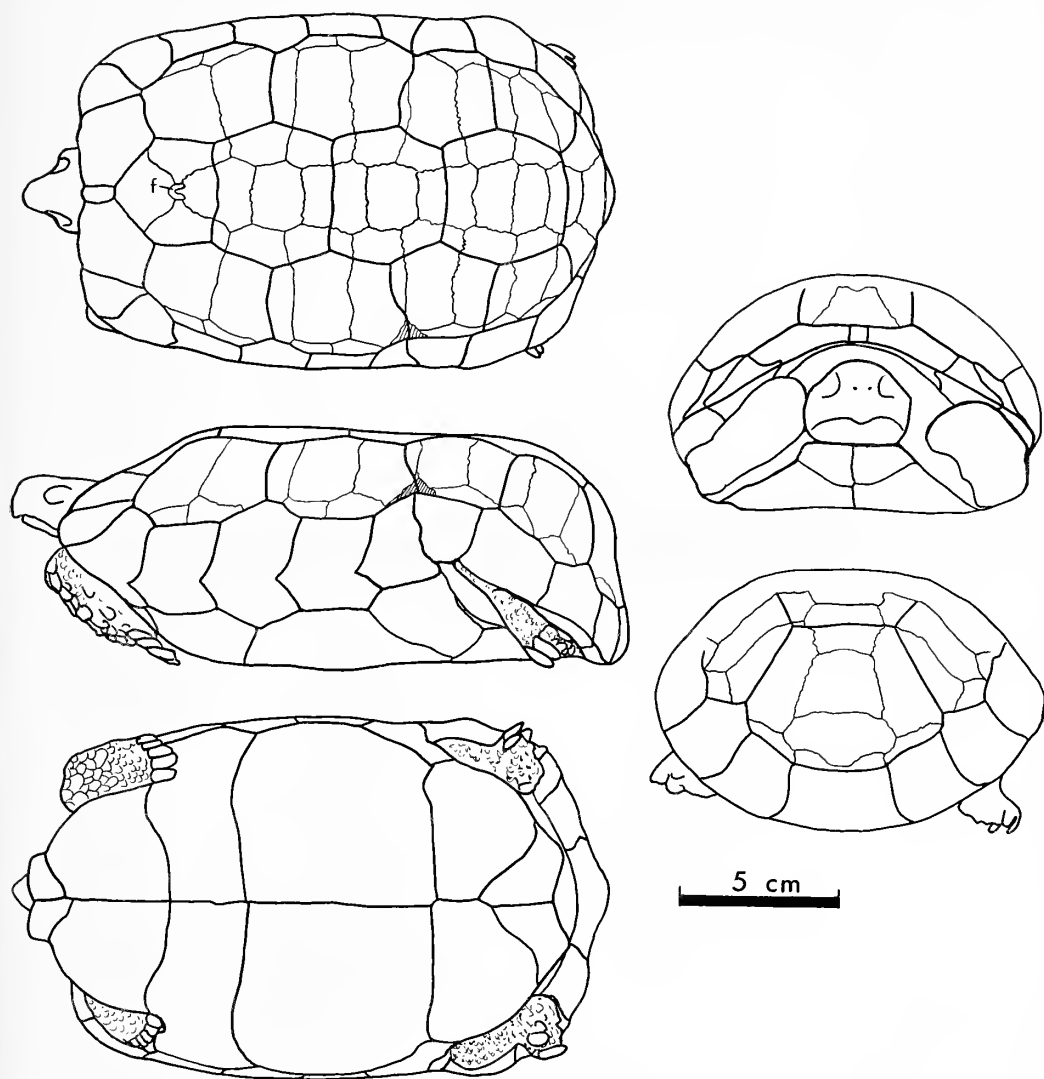


Fig. 11. *Kinixys belliana spekii*. AM 78C, lectotype ♀ of *K. australis* Hewitt from White River, E. Transvaal. Dorsal, lateral, ventral, anterior and posterior views. Conventions as in Fig. 8. f = fontanelle.

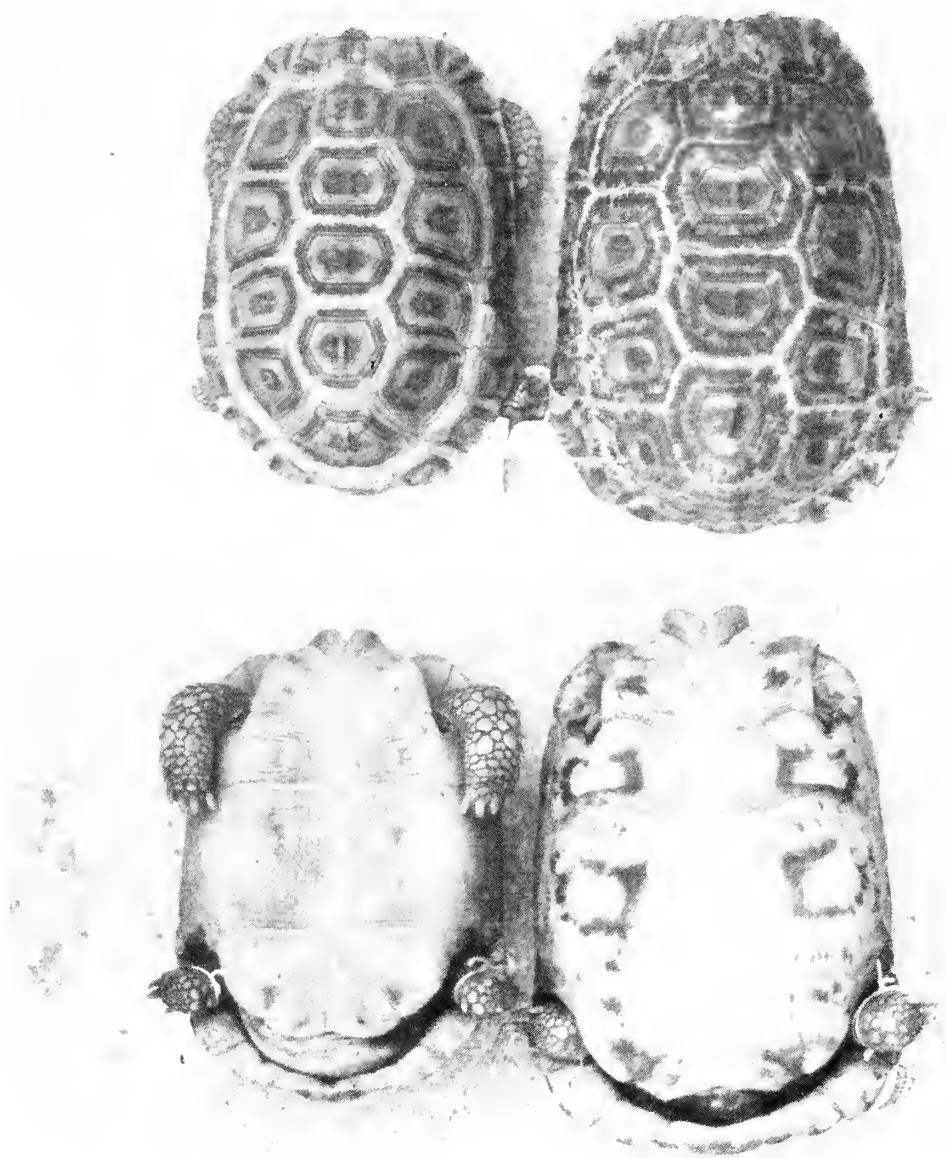


Fig. 12. *Kinixys belliana spekii*. Left, ♂ UM 30450; Right, ♀ UM 30451; both from 10 km SSE of Ressano Garcia, Moçambique, dorsal and ventral views.

*Distribution.*

Savannas of much of southern and central Africa excluding the eastern coastal strip inhabited by typical *K. belliana*. Range extends north at least to Angola, southern Zaire, western Tanzania and Kenya (Loveridge, 1936).

*Localities.*

TRANSVAAL: Farm De Hoop, Nelspruit TM 42393; Komatipoort (Archer, 1967, 1968); Kruger National Park (Pienaar, 1966, 1978; Switak, 1971); White River (Hewitt, 1931 AM 77 (5), 1295 MOÇAMBIQUE: Maputo Elephant Reserve TM 41761 (this specimen may be a waif from further west, perhaps swept into a tributary of the Maputo River by a flash flood); Moamba TM 29516-7; 10 km SSE of Ressano Garcia UM 30450-1, 30455, 33010; 15 km SSE of Ressano Garcia UM 30452. SWAZILAND: near Manzini TM 24205; north of Manzini TM 42735; 5 km NW of Siphofaneni TM 51023; Tshaneni UM 33418. ZULULAND: Ndumu Game Reserve TM 37895. NATAL: Weenen Nature Reserve TM 52219.

## ACKNOWLEDGEMENTS

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Mrs F. M. Clift typed the manuscript, Mr M. L. Angell took the photographs and Mr & Mrs J. Akester printed them.

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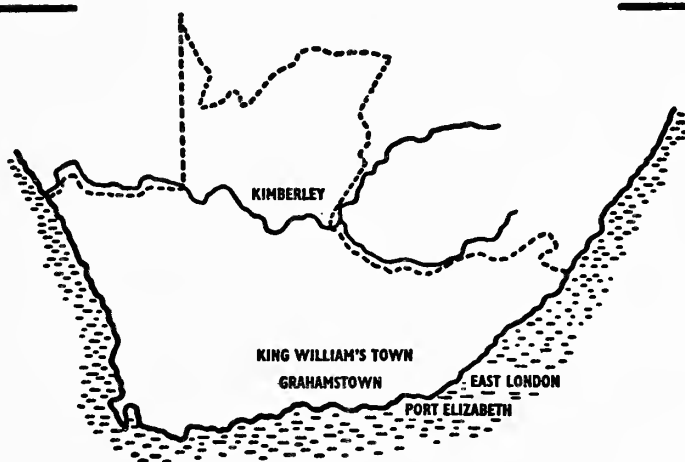
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# The description and osteology of a new species of *Gephyroglanis* (Siluriformes, Bagridae) from the Olifants River, South West Cape, South Africa

by

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## ABSTRACT

A new small bagrid catfish referred to *Gephyroglanis* is described from the Olifants River, western Cape Province, South Africa. The osteology of the new species is described and figured. Comparisons with other South African *Gephyroglanis* species are drawn and queries concerning the generic placement of these species are raised.

## INTRODUCTION

The Olifants River system in the south-western Cape Province (Fig. 7) has a particularly high proportion of endemic fish species. One of these, *Gephyroglanis gilli* Barnard, 1938, is a relatively small bagrid catfish. A second *Gephyroglanis* species, *G. sclateri* Boulenger, 1901, occurs in the Orange River system to the north. Other *Gephyroglanis* species, found in the Zaire River and in rivers of West Africa (Boulenger, 1911; Jayaram, 1966), are remote from the southern African species.

Barnard (1943) commented on the intraspecific variation of both southern African *Gephyroglanis* species pointing out that two rather distinct "fin forms" are found: one with a high ragged dorsal fin and the other with a low dorsal fin. Barnard *op. cit.* (p. 229) remarked that if the extremes of each form were taken from different river systems they could "almost be regarded as constituting a specific difference". He considered, however, that the differences were phenotypic in nature, the high fin form coming from rocky, flowing waters and the low fin form from placid, muddy waters.

During routine identification of fishes from a survey of the Olifants River system conducted by the Department of Nature and Environmental Conservation, the author was impressed by the remarkable difference of fin form between specimens of *Gephyroglanis*. Further investigations revealed that the differences of fin form were correlated with other characters which, contrary to Barnard's finding, indicated specific distinction. Re-examination of existing collections revealed that several, including the syntype series of *G. gilli*, contained two clearly different species of which one is referable to *G. gilli* and the other is here described as new.

## METHODS

Measurements were taken to the nearest 0,1 mm and are expressed as percentages of standard length.

Linear measurements (Fig. 1) were made according to Hubbs & Lagler (1958) except for the following:

*Pectoral to pelvic fin length* is the median measurement between the posterior margins of the bases of the pectoral and pelvic fins.

*Pelvic to anal fin length* is the median measurement between the posterior margin of the base of the pelvic fin and the base of the first anal fin ray.

*Predorsal length* is measured from the symphysis of the premaxillae to the base of the first dorsal fin spine.

*Humeral process length* is measured from the base of the pectoral spine to the tip of the humeral process.

Vertebral counts were determined from radiographs. Counts were taken according to Skelton (1976).

Anal fin rays were counted as far as possible by dissection. The number of anterior unbranched rays is nevertheless difficult to determine accurately because these rays are fine and small. Completely reliable counts are available from six cleared and stained specimens.

Specimens were cleared and stained for bones and cartilage using Taylor and Van Dyke's (1979) modified trypsin method (Alcian blue for cartilage, alizarin red for bone).

SKELTON: DESCRIPTION AND OSTEOLOGY OF GEPHYROGLANIS

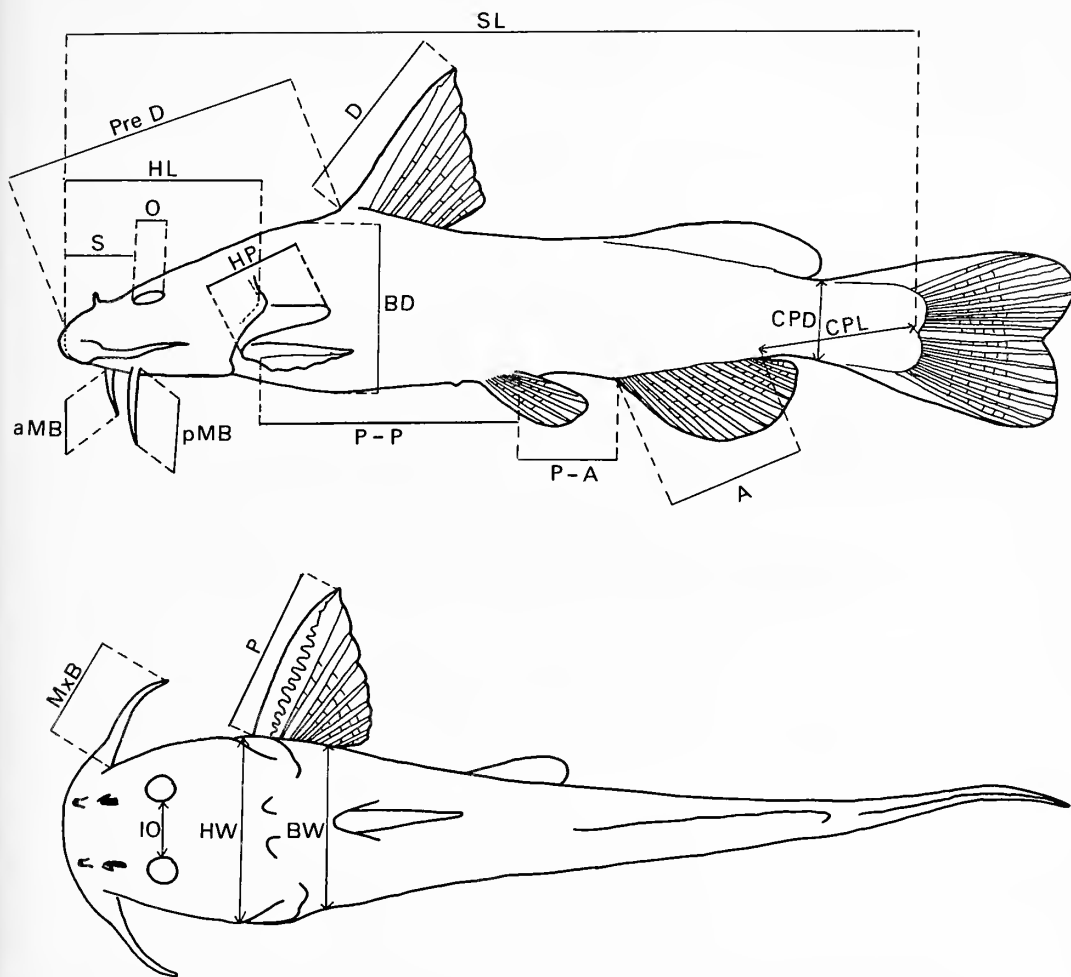


Fig. 1. Measurements as made in this study on *Gephyroglanis*.

Abbreviations: A—anal fin base; aMB—anterior mandibular barbel; BD—body depth; BW—body width; CPD—caudal peduncle depth; CPL—caudal peduncle length; D—dorsal fin length; HL—head length; HP—humeral process length; HW—head width; IO—inter orbit; MxB—maxillary barbel; O—orbit diameter; P—pectoral fin length; P-A—pelvic to anal fin; P-P—pectoral to pelvic fin; pMB—posterior mandibular barbel; Pre D—predorsal length; S—snout length; SL—Standard length.

Abbreviations: AM/P—Albany Museum fish collection, Grahamstown; BMNH—British Museum (Natural History), London; MNHN—Muséum National d'Histoire Naturelle, Paris; MRAC—Musée Royal de l'Afrique Centrale, Tervuren; USNM—United States National Museum (specimens in National Museum of Natural History, Smithsonian Institution), Washington; RUSI—J. L. B. Smith Institute of Ichthyology, Grahamstown; SAM—South African Museum, Cape Town.

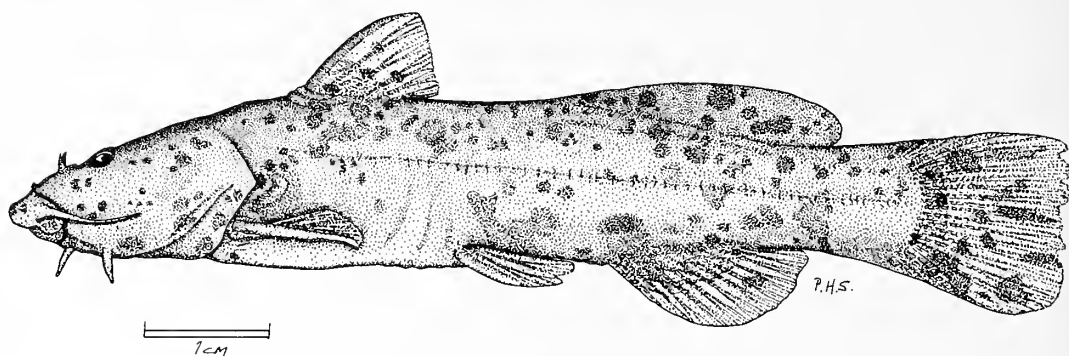


Fig. 2. Holotype of *Gephyroglanis barnardi* sp. nov., male of 68,5 mm SL. AM/P 7647 (a)

## DESCRIPTION

*Gephyroglanis barnardi* sp. nov.

Barnard's rock catlet (Fig. 2)

### Material examined

Holotype: AM/P 7647 (a) ♂ 68,5 mm SL. Noordhoeks River at roadbridge, tributary of Olifants River, Cape Province, S.A. (32° 43' 15"S; 19° 03' 59"E). Electrofished by K. Hamman & S. Thorne, 3 September 1979.

Paratypes: 3, AM/P 7647 (b) 71 mm SL; 57,4 mm SL, 51,5 mm SL. Collected together with holotype. 29, (ex) AM/P 1369 33,5–67,2 mm SL. Collected at same site as holotype by F. L. Farquharson, 7 April 1967. (5 specimens sent to BMNH, 5 to USNM, 5 to MNHN). 14, AM/P 1879 (4 cleared and stained). Collected at same site as holotype by K. van Rensburg, 17 March 1965. (5 specimens to RUSI). 7, AM/P 893 (2 cleared and stained). Collected at same site as holotype by K. van Rensburg, 17 March 1965. 7, SAM 29232. Collected by K. H. Barnard and C. W. Thorne, Noordhoeks River and Olifants River mainstream at Keerom, February 1939, (ex-type series of *G. gilli*).

Other Material: 1, AM/P 8202, ripe 74,5 mm SL. Noordhoeks River at roadbridge. Electrofished by P. H. Skelton and S. Thorne, 6 January 1981. 1, AM/P 8206, ripe 5 mm SL, Thee River (32° 47' 49"S, 19° 05' 31"E). Electrofished by P. H. Skelton and S. Thorne, 7 January 1981.

### Diagnosis

*G. barnardi* is relatively small, the longest specimen examined is 75 mm SL. Morphometric proportions recorded in Table 1. Head depressed and flat with squarish profile from above, 6,6 to 8 times in SL, broadest at level of the opercle, dorsal surface entirely covered by skin. Angle of head shallow (20–30°) rising straight or with a very shallow arch to the nape and dorsal fin. Eyes dorso-lateral, small, directed dorsally and widely spaced; mouth straight, sub-terminal with moderately papillose and fleshy lips.

Nares widely separate, located antero-medial to orbits; anterior short and tubular, posterior elongated. Each posterior naris bordered in front with a short compressed barbel (Fig. 4) the base of which extends posteriad as a low narrow ridge on either side of the naris. Snout bluntly curved.

SKELTON: DESCRIPTION AND OSTEOLOGY OF GEPHYROGLANIS

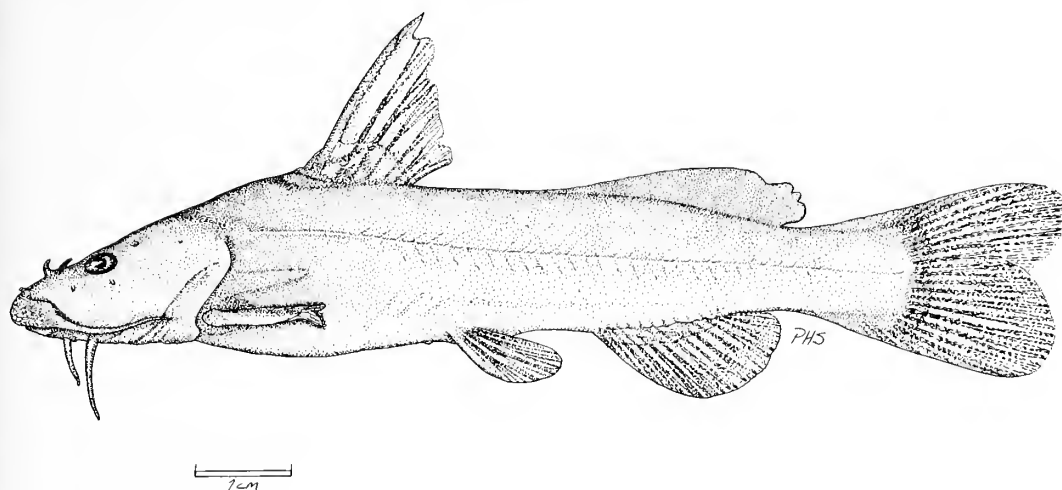


Fig. 3. *Gephyroglanis gilli* Barnard, male of 97,4 mm SL. AM/P 7646 collected in same locality as holotype of *G. barnardi*.

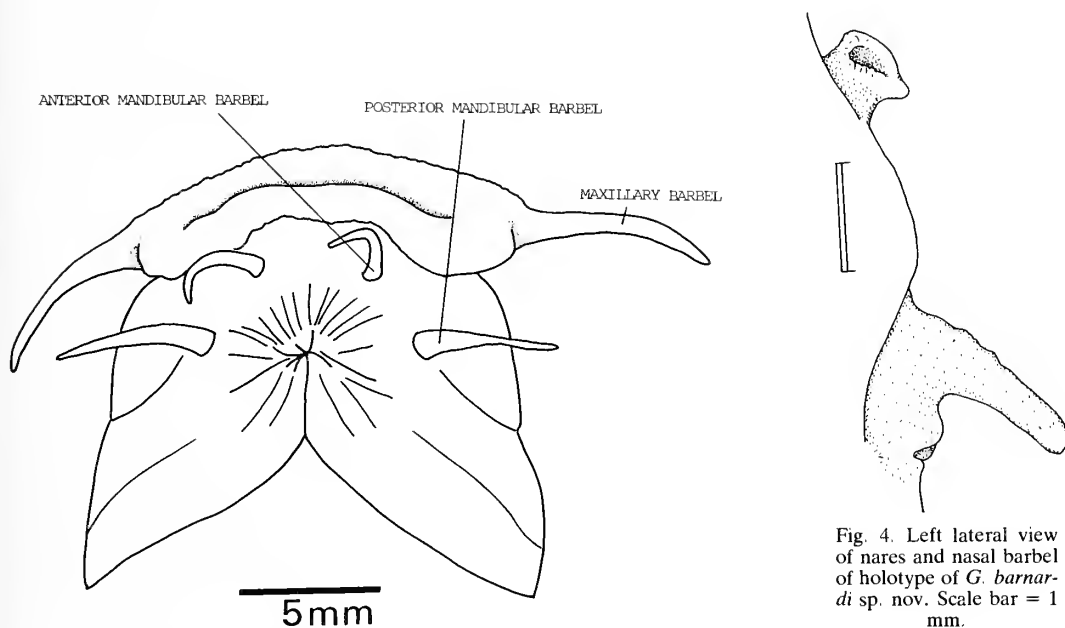


Fig. 5. Ventral view of head of holotype of *G. barnardi* sp. nov. to show mouth form and position of mandibular barbels.

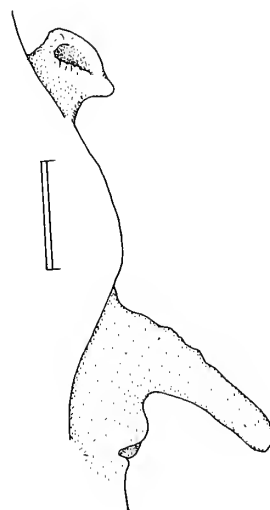


Fig. 4. Left lateral view of nares and nasal barbel of holotype of *G. barnardi* sp. nov. Scale bar = 1 mm.

TABLE 1.  
Comparative measurements (%SL) of southern African Gephyroglanis species: *G. barnardi* holotype and paratypes; *G. gilli*—AM/P 1369; *G. sclateri* AM/P 3921 (3), 1477 (8), 7840 (1), 1383 (7). Measurements of holotype in mm.

	<i>G. barnardi</i>						<i>G. gilli</i>						<i>G. sclateri</i>					
	Holotype	Min	Max	M	SD	SE	Min	Max	M	SD	SE	Min	Max	M	SD	SE		
Head length.....	25.3	24.0	27.1	25.5	0.7	0.1	19.5	28.6	25.8	1.8	0.4	23.3	26.7	25.0	0.8	0.2		
Head depth.....	14.6	12.8	15.5	14.0	0.7	0.1	12.9	15.81	14.3	0.8	0.2	11.1	16.3	14.4	1.2	0.3		
Head width.....	22.5	19.4	23.3	21.5	0.9	0.1	19.6	22.9	21.3	1.0	0.2	18.7	22.2	20.8	0.9	0.2		
Orbit.....	2.8	2.8	3.9	3.5	0.2	0.03	3.4	5.3	4.2	0.6	0.1	3.2	5.0	4.2	0.5	0.1		
Interorbit.....	8.5	6.6	9.5	8.2	0.7	0.1	6.3	7.8	7.3	0.5	0.1	7.4	8.9	8.1	0.4	0.1		
Snout.....	10.5	9.8	11.5	10.5	0.4	0.1	9.6	12.4	11.0	0.7	0.2	11.0	13.1	11.8	0.7	0.2		
Body Depth.....	19.0	14.7	19.4	16.6	1.1	0.2	15.3	20.8	18.1	1.3	0.3	17.1	24.4	20.5	1.8	0.4		
Body Width.....	18.7	16.4	20.1	18.3	0.8	0.1	16.9	20.4	18.8	0.9	0.2	17.2	21.1	19.5	1.1	0.2		
Caudal Peduncle Length.....	20.4	18.5	23.2	20.5	1.1	0.2	14.7	20.8	17.7	1.6	0.4	16.2	21.4	18.5	1.3	0.3		
Caudal Peduncle Depth.....	11.2	8.7	11.3	10.0	0.6	0.1	8.4	10.0	9.0	0.4	0.1	8.9	10.5	9.9	0.4	0.1		
Dorsal Fin Height.....	17.1	14.3	18.8	16.9	1.0	0.1	19.1	25.5	21.4	1.8	0.4	17.1	24.0	21.0	1.8	0.4		
Pectoral Fin Length.....	17.2	16.3	20.1	17.9	1.0	0.2	17.1	23.7	20.2	1.8	0.4	15.4	20.3	18.1	1.2	0.3		
Pelvic Fin Length.....	13.4	10.7	16.7	12.5	1.0	0.1	10.1	14.9	12.3	1.2	0.3	10.7	15.6	12.3	1.2	0.3		
Base of Anal Fin.....	17.2	14.7	20.5	17.3	1.0	0.2	13.8	18.7	15.9	1.2	0.3	13.6	18.2	15.7	1.5	0.3		
Maxillary Barbel.....	9.3	7.9	12.8	9.8	1.2	0.2	8.5	16.1	12.4	2.0	0.4	7.3	11.9	9.2	1.1	0.3		
Anterior Mandibular Barbel.....	5.8	4.4	6.8	5.5	0.6	0.1	4.2	8.1	6.3	1.2	0.3	2.7	5.3	4.5	0.7	0.2		
Posterior Mandibular Barbel.....	8.0	6.3	10.7	8.7	1.0	0.1	7.5	14.9	10.5	2.0	0.5	4.4	10.7	8.1	1.3	0.3		
Pectoral—Pelvic Length.....	25.4	21.5	26.6	24.3	1.1	0.2	20.9	26.1	23.7	1.4	0.3	22.3	27.3	24.8	1.5	0.3		
Pelvic—Anal Length.....	15.0	13.4	18.2	15.5	1.3	0.2	11.1	17.8	14.3	1.5	0.3	12.7	17.8	15.1	1.4	0.3		
Predorsal Length.....	32.7	30.9	34.8	32.6	0.9	0.1	32.4	37.2	34.7	1.3	0.3	32.8	37.4	34.9	1.3	0.3		
Humeral Process.....	6.6	5.0	8.7	7.0	0.8	0.1	10.0	14.2	12.3	1.1	0.3	9.3	11.1	10.2	0.6	0.1		

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Gill openings continuous ventrally and ascending on either side to the dorso-lateral surface of head. Branchiostegal membranes free. Branchiostegal rays 6-6 (N 6).

Four pairs of barbels present including the short nasal pair described above, a pair of simple maxillary barbels and two pairs of simple mandibular barbels. Maxillary barbels extending lateral from upper jaw, not reaching beyond posterior opercular groove. Anterior mandibular barbels placed ventrally just posterior to lower lip (Fig. 5). Posterior mandibular barbels slightly longer than anterior pair, located behind and lateral to the anterior pair opposite the gular node (Fig. 5).

Body broadest anteriorly becoming increasingly compressed caudad. Caudal peduncle laterally compressed, twice as long as deep. Anus located posterior to base of pelvic fins and covered by fan of pelvics. Skin smooth.

Dorsal fin short, with straight posterior edge, basal third fleshy. Dorsal fin spine without serrations. Pectoral fins rounded. Anterior ray gently curved and spinous, serrated on postero-medial edge with 6 (juveniles) to 12 or 13 (usually 10 or 11 in adults) basally directed serrations. Pectoral fin formula I (N 54), 6 (N 4), 7 (N 50).

Pelvic fins rounded overlapping ventrally and short, not reaching anal fin. Pelvic fin formula I, 5 (N 54).

Anal fin rounded, fleshy over basal third, formula in Table 2.

Last anal ray divided or undivided to base. Caudal fin irregularly truncate, extending anteriorly on the dorsal and ventral edges of caudal peduncle. Principal caudal rays usually 8 + 9 (N 40), less frequently 9 + 8 (N 7); 9 + 9 (N 2); 7 + 9 (N 1); 7 + 8 (N 2); 8 + 8 (N 2) (holotype has 9 + 8). Procurrent rays as determined from cleared specimens: dorsal 16 (N 4), 17 (N 1), 18 (N 1); ventral 15 (N 1), 17 (N 4), 18 (N 1) (Table 4).

Adipose fin long and well developed, originating behind pelvic fin base, posteriorly detached.

Cephalic lateral line system unfragmented, course of canals shown in Fig. 9.

Lateral line straight, simple, extending mid-laterally from head to posterior end of caudal peduncle.

Alimentary canal (Fig. 6) short, with stomach expanded, bulbous and leading to the intestine on the left. Intestine crosses anteriorly to right before passing posteriorly ventro-laterally and tucking behind the stomach. Thereafter it proceeds directly to the anus.

Gonads paired, ovaries simple, testes villiform.

Vertebral counts are recorded in Table 3.

TABLE 2.

*Distribution frequency of anal fin rays (A) G. barnardi N=54 (B) G. gilli N=20 (C) G. sclateri N=20*

		Branched rays											
		A				B				C			
		10	11	12	13	10	11	12	13	10	11	12	13
Unbranched Rays	iii		1	2	1								
	iv	6	16	7	1								
	v	4	9	3	1	6	6	1	1	1	3	3	1
	vi	1	2			3	1	1			3	8	

TABLE 3.

*Comparative distribution frequencies of vertebral counts of South African Gephyroglanis species**A. VERTEBRAE*

	N	41	42	43	44	45	46	47
<i>G. barnardi</i>	(32)		2	19	10	1		
<i>G. gilli</i>	(20)	1	9	10				
<i>G. sclateri</i>	(5)						1	4

*B. PRECAUDAL VERTEBRAE*

	N	11	12	13	14	15	16	17
<i>G. barnardi</i>	(32)		15	10	6	1		
<i>G. gilli</i>	(20)	3	7	9	1			
<i>G. sclateri</i>	(5)					1	3	1

*C. CAUDAL VERTEBRAE*

	N	28	29	30	31	32
<i>G. barnardi</i>	(32)		5	10	12	5
<i>G. gilli</i>	(20)	1	4	10	4	1
<i>G. sclateri</i>	(5)			2	2	1

*D. PREANAL FIN VERTEBRAE*

	N	19	20	21	22	23	24
<i>G. barnardi</i>	(32)		3	21	8		
<i>G. gilli</i>	(20)	2	8	8	2		
<i>G. sclateri</i>	(5)				2	1	2

TABLE 4.

*The number of caudal procurent rays in six cleared and stained paratypes of Gephyroglanis barnardi*

		Dorsal Procurent Rays		
		16	17	18
Ventral	15		1	
Procurent	16			
Rays	17	3		1
	18	1		



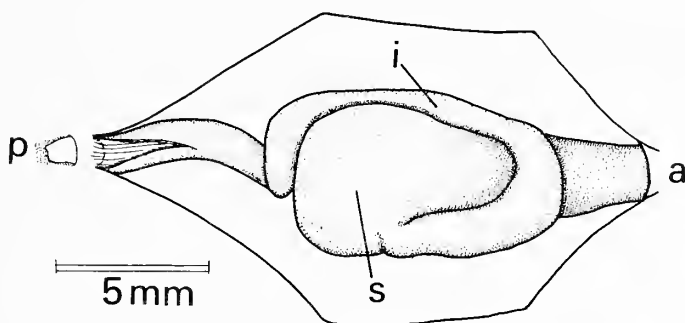


Fig. 6. Alimentary canal within the body cavity of *Gephyroglanis barnardi* sp. nov. (AM/P 1879 No. 2). Abbreviations: a—anterior; p—posterior; i—intestine; s—stomach.

#### Comparison with *Gephyroglanis gilli* and *G. sclateri*

*Gephyroglanis barnardi* may be distinguished from the sympatric *G. gilli* by the following characteristics: it is a smaller species (maximum recorded SL = 71 mm v. 127 mm of *G. gilli*); *G. barnardi* has dark brown spots and blotches, *G. gilli* is invariably without blotches or markings; *G. barnardi* has more slender curved dorsal and pectoral fin spines and these fins are shorter and more rounded than those of *G. gilli* which has well developed strong dorsal and pectoral spines and longer, straight, angulate fins (Fig. 3); the posterior edge of the caudal fin is more or less truncate in *G. barnardi*, in *G. gilli* this is emarginate (Figs 2 & 3); *G. barnardi* has fewer dorsal branched rays (six) than *G. gilli* (seven).

*G. barnardi* differs in several morphometric and osteological characters from *G. gilli*, particularly in having a smaller eye, shorter barbels, shallower head and body depth, shorter humeral process, nuchal plates separate from the supraoccipital process (in *G. gilli* the nuchal plates of the dorsal fin interlocks with the supraoccipital process), the caudal fin skeleton relatively consolidated (i.e. fused) compared with *G. gilli*, more vertebrae than *G. gilli* (Table 3).

*G. barnardi* is distinguished from *G. sclateri*, an Orange River endemic species, by its smaller maximum size, smaller eye, shorter snout, shallower body depth, longer caudal peduncle, shorter dorsal fin, number of branched dorsal fin rays, shorter humeral process and in the position of the posterior mandibular barbels. In addition the cephalic lateral line pores of *G. barnardi* are simple, those of *G. sclateri* are dendritic. The caudal fin of *G. barnardi* is truncate whereas that of *G. sclateri* is moderately forked. The caudal skeleton is more consolidated in *G. barnardi*. The supraoccipital process is joined with the first nuchal plate in *G. sclateri* but not in *G. barnardi*. There are fewer vertebrae in *G. barnardi* than in *G. sclateri* (Table 3).

#### Distribution, habitat preferences and status

*G. barnardi* is known only from the Noordhoeks and Thee rivers, two adjacent tributaries of the Olifants River system of the western Cape Province (Fig. 7). Both these tributaries are perennial mountain streams with gradients of approximately 1:30 (Noordhoeks) and 1:45 (Thee) over the accessible reaches where the species has been collected. The streams vary in width from three to six or seven metres wide during normal flow and are bedded with loose round rocks, pebbles and coarse clean sand. Vegetation is generally restricted to marginal

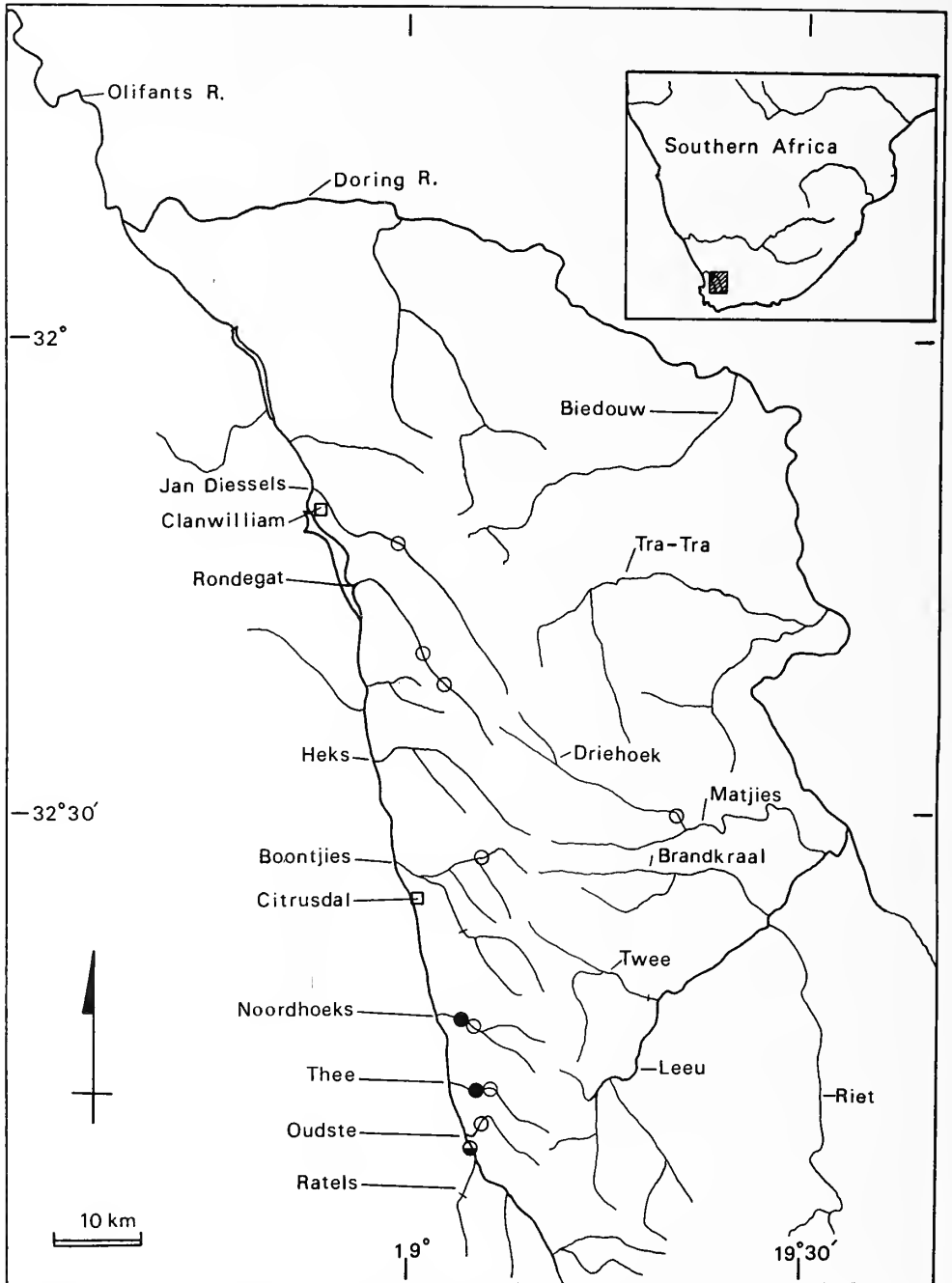


Fig. 7. The distribution of *Gephyroglanis barnardi* sp. nov. (closed circles) and *G. gilli* (open circles) in the Olifants River system, western Cape Province. Records as given in list of type material (*G. barnardi*) and in Appendix 1 (*G. gilli*). Half closed circle refers to SAM 19359/SAM 29232 from which either or both species may have been collected.

patches, frequently of Cyperaceae. Riffles and shallow runs alternate with deeper pools and the water is clear. *G. barnardi* is found together with *G. gilli* and the redfin minnow, *Barbus phlegethon*, in shallow (less than 1 m deep) flowing riffle stretches.

The confinement of *G. barnardi* to these two tributaries is surprising. Barnard may have collected this species from the mainstream at Keerom (cf SAM 29232) but it is possible that his specimens of *G. barnardi* may have been derived only from Noordhoeks as the evidence is equivocal. The habitat of the mainstream at Keerom is very similar to that in the Noordhoeks and Thee except that it is deeper, up to about two metres. Extensive surveys by the author and officials of the Department of Nature and Environmental Conservation throughout the Olifants system indicate that the species is probably restricted to these two streams and possibly to a few other adjacent streams in inaccessible localities. This restriction may be due in part to specific habitat preferences—which appear similar to those of *B. phlegethon*. This minnow species occurs almost exclusively in such shallow flowing, loose rock and pebble bottomed habitats of the clear water western Cedarberg tributaries of the mainstream Olifants River. The two strongest populations of *B. phlegethon* are those in the Noordhoeks and Thee rivers.

It is also likely that ecological changes in the Olifants River system resulting from human interference have acted to restrict *G. barnardi* and other indigenous species including *B. phlegethon* (Gaigher, 1978; Skelton, 1977). Agricultural practices and the introduction of exotic predatory fish species, notably smallmouth bass (*Micropterus dolomieu*) are undoubtedly the main factors involved (pers. obs.). From available records it would appear that *G. barnardi* is probably the rarest species in the Olifants and is therefore clearly an endangered species.

#### Etymology

The species is named for the late Dr Keppel Harcourt Barnard, former Director of the South African Museum. This name is particularly fitting because both of the other southern African *Gephyroglanis* species are named after Dr Barnard's predecessors at the South African Museum and furthermore Dr Barnard himself described *G. gilli* with which *G. barnardi* has been confused in the past. Finally it is clear from his writings that Dr Barnard had a particular interest in the fish fauna of the Clanwilliam Olifants River.

#### OSTEOLOGY

The following description of the osteology of *G. barnardi* is provided in order to form a base line study to which other *Gephyroglanis* species can be compared. The osteology of *G. sclateri* has been described by Petrick (1976) but that description is not generally available. Bone names are those in general usage (mainly after Weitzman, 1962) except in the following cases: Gosline (1975) for suspensorium; branchial and hyoid arches from Nelson (1969); epioccipital follows Paterson (1975); supracleithrum and posttemporal after Lundberg (1975); Weberian vertebrae follow the homology suggested by Chardon (1968). The term ethmoid is used here for the bone referred to as the mesethmoid or supraethmoid of various authors. Patterson (1975) has shown this bone to be derived from a supraethmoid and rostrodermethmoid.

#### Neurocranium (Figs 8a, b, c, d)

The *ethmoid* is a T-shaped bone, sutured postero-ventrally with the lateral ethmoids and the vomer and interdigitating postero-dorsally with the frontal and lateral ethmoids. The ethmoid is visible on the ventral side only as a narrow neck linking the broad premaxillae with the neurocranium.

The *premaxillae* are broad rectangular plates firmly attached to the ventral side of the T-bar of the ethmoid. Their ventral surface is almost entirely covered with slender, curved, sharp conical (macroscopically villiform) teeth.

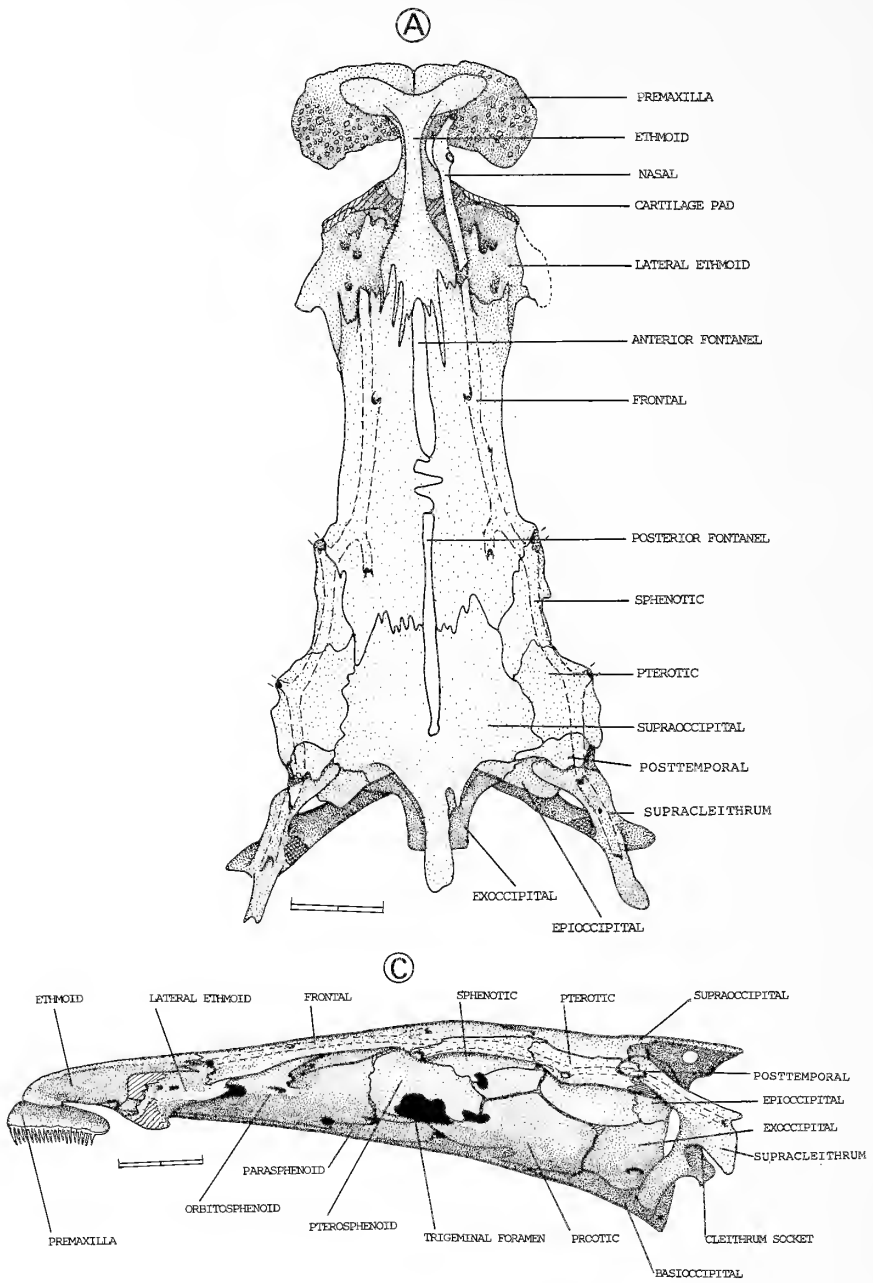
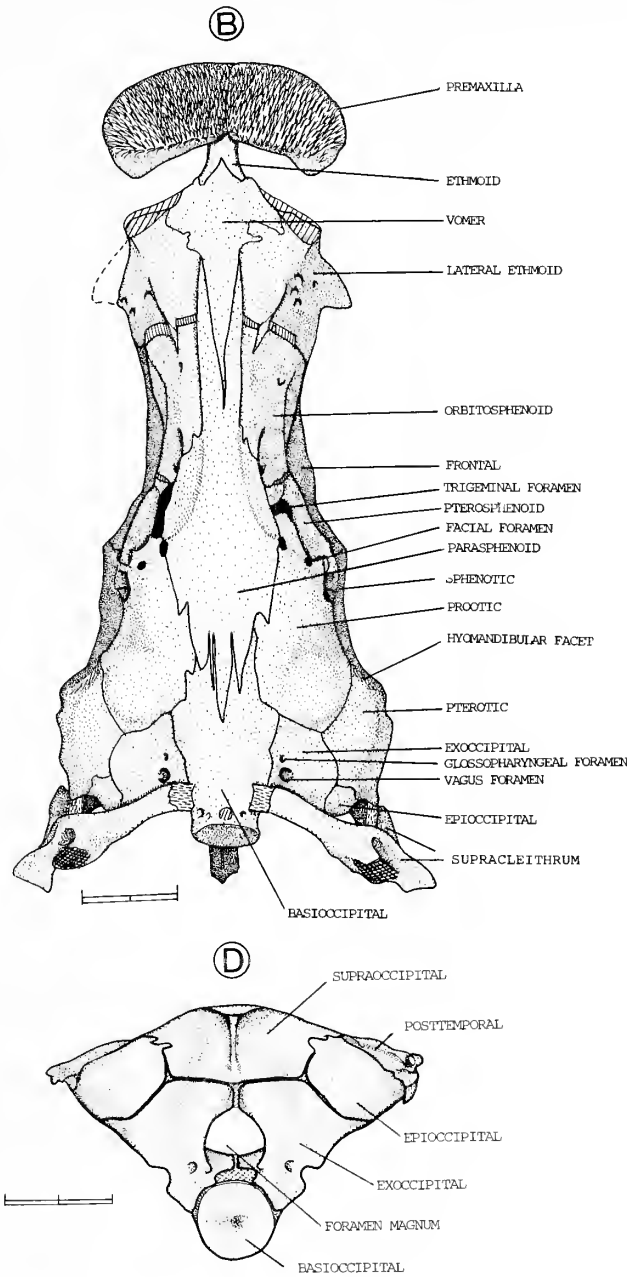


Fig. 8. Neurocranium of *Gephyroglanis barnardi* sp. nov. left nasal bone removed; B. ventral view

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(W/P 893). Scale bar = 2 mm. A. dorsal view, C. left lateral view; D. posterior view.

The *lateral ethmoids* are prominent bones forming broad synchondral sutures posteriorly with the orbitosphenoids, dorsally with the frontals and anteriorly with the ethmoid. Antero-medially the lateral ethmoids are partially overlapped by thin lateral lamellae of the vomer. Their anterior and antero-ventral margin is encased in cartilage to form an articulation condyle for each palatine. The *vomer* is a blade-like bone articulating on the postero-ventral surface of the ethmoid and the antero-medial surface of each lateral ethmoid.

The canal-bearing *frontals* are elongated rectangular bones sutured anteriorly with the lateral ethmoids and supraethmoid and posteriorly with the supraoccipital and sphenotic bones. Each frontal counteroverlaps the other along a sinuous medial suture, except where the bones are separated to form elongated anterior and posterior fontanelles.

The *sphenotic*, *pteric*, *supratemporal* and *supraoccipital* bones form the posterior roofing bones of the neurocranium. The *sphenotics* lie postero-laterally to the frontals, anteriorly to the pterotics and usually latero-anteriorly to the supraoccipitals. The neurocranium broadens at the level of the *pteric* and these bones form the postero-lateral portion of the braincase. Each pterotic provides passage for a portion of the posttemporal canal of the cephalic lateral line system, as well as internally for the horizontal semicircular canal. A shallow hyomandibular facet is formed jointly by the pterotic and sphenotic bones. The large pan-shaped *supraoccipital* extends over the postero-medial portion of the neurocranium. Anteriorly a deep medial notch in the supraoccipital forms the posterior part of the posterior fontanel. Posteriorly a slender medial process extends towards but does not reach the first nuchal plate of the dorsal fin skeleton.

The *parasphenoid* forms a narrow strut anteriorly where it is partially overlapped by the vomer. On the dorsal side it is sutured in turn to the lateral ethmoids, orbitosphenoids and prootics. Posteriorly the parasphenoid interdigitates with the basioccipital.

Anteriorly the *orbitosphenoid* forms a dual synchondral suture divided by a groove and foramen with the lateral ethmoids. Dorsally each orbitosphenoid meets the respective frontal along a simple suture. Posteriorly there are synchondral sutures with the pterosphenoids. The orbitosphenoids are closely applied to the parasphenoid without an inter-orbital septum being formed.

The *pterosphenoids* meet the frontals on the antero-dorsal side, the sphenotics postero-dorsally and, over a short length, the parasphenoids ventrally. Anteriorly the pterosphenoids are synchondrally united to the orbitosphenoids. Posteriorly and postero-ventrally an irregular junction with the prootics allows for the formation of the large trigeminal foramen. A smaller facial foramen also provides a break in the suture between each pterosphenoid and prootic.

The large *prootics* form hemispherical bulges (*bulla acustica lagenaris*) on the ventral surface of the neurocranium. Anteriorly the prootics suture with the pterosphenoids, dorsally with the sphenotics and the pterotics, ventrally with the parasphenoid, postero-ventrally with the basioccipital and posteriorly with the exoccipitals.

The *basioccipital* forms an interdigitating suture anteriorly with the parasphenoid, and is synchondrally sutured to either prootic antero-laterally and the exoccipitals laterally. The ventral limb of the posttemporal is attached to the postero-lateral sides of the basioccipital by means of a ligament. The basioccipital houses the major portion of each sagitta and, in part, each asteriscus.

The *exoccipitals* suture with the basioccipitals laterally and dorsally. They include both the glossopharyngeal (IX) and vagus (X) foramina. The foramen magnum is bounded by the exoccipitals (latero-dorsally) with a small portion provided by the basioccipitals on the ventral side. (Lamellae of the exoccipitals meet in the midline to form the posterior floor of the brain case.)

The *epioccipitals* are sutured to the exoccipitals, supraoccipitals, and pterotics and are overlain by the supratemporals and, in part, the posttemporals. The dorsal section of the posterior

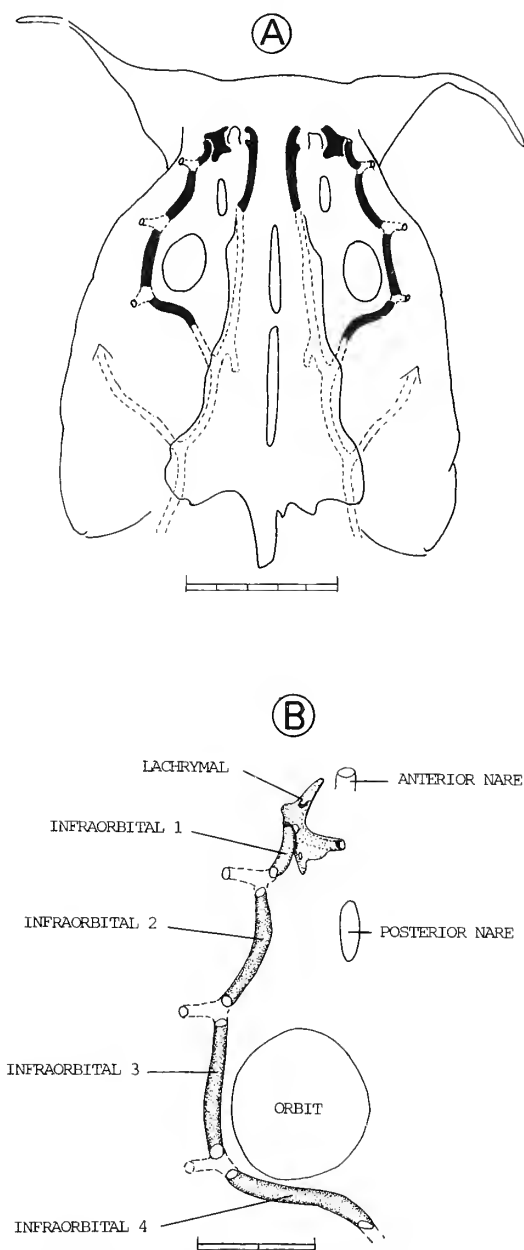


Fig. 9. A. Diagram of dorsal view of head of *Gephyroglanis barnardi* sp. nov. to illustrate *in situ* position of nasals, infraorbital bones, lachrymal and the course of the cephalic lateral line system. Note preoperculomandibular lateral line canal extends to dentary (cf. Fig. 12). B. Infraorbital bones and lachrymal of *Gephyroglanis barnardi*.

vertical semi-circular canal passes obliquely through each epioccipital providing passage from the exoccipitals, which continues dorsally into the supraoccipital.

The *posttemporals* are small plates overlying the epioccipitals and articulating with the extremity of the dorsal limb of the supracleithrum. A short canal through the posttemporal links the supracleithral portion with the pterotic portion of the cephalic lateral line canal.

The *supracleithra* are large V-shaped bones each with a dorsal limb articulating in a groove between the epioccipital and the supratemporal. A channel through this limb provides passage for the cephalic lateralis lateral line canal. The ventral limb is attached from its medial extremity to the side of the basioccipital. At the lateral base of the ventral limb a large round groove or cavity, closed posteriorly by tough connective tissue, accommodates the dorsal extremity of the cleithrum.

*Infraorbitals and nasal bones (Figs 8a, 9a and b)*

The *nasal bones* are elongate tubular units lying lateral to the stem of the ethmoid. They have a short branch leading to an opening about midway along their length and their rostral end turns laterad. The *infraorbital* series are tubular bones comprising a triradiate lachrymal, a short first infraorbital and three longer, gently curved second, third and fourth infraorbitals. The lateral line canal branches to a pore at each interconnection.

*Suspensorium, palatine-maxilla and preopercular (Figs 10a and b, 11, 12).*

The *hyomandibular*, *preopercular*, *quadrate* and *metapterygoid* are welded together to form a large plate-like unit. The *hyomandibular* articulates in a facet formed by the sphenotic and pterotic and also has a posterior spherical facet with which the opercle articulates. Anteriorly it sutures by means of an interdigitation with the metapterygoid. Ventrally it is sutured with the preopercle. There is an arcuate symplectic-cartilage between the hyomandibular and the quadrate on the antero-ventral edge of the former bone. A canal through the hyomandibular provides passage for the facial nerve which passes medio-dorsally—latero-ventrally and emerges laterally from a notch on the preopercular. There is a narrow lateral ledge on the hyomandibular providing attachment for the levator arcus palatini muscle.

The *preopercle* is firmly sutured dorsally to the hyomandibular and the quadrate. Antero-ventrally a ledge of the quadrate lies lateral to the preopercle, on the posterior side a flange of the preopercle lies lateral to the quadrate. The flange also covers portions of the symplectic cartilage and the hyomandibular. The lateral line canal passes through the length of the preopercle with two intermediate branches to pores terminating on the ventral edge of the bone.

The *quadrate* is stout and squarish, forming an arcuate synchondral junction with the hyomandibular dorsally, an interdigitating suture with the metapterygoid anteriorly and is sutured posteriorly with the preopercle.

The *metapterygoid* is the smallest bone in the unit and forms interdigitating sutures ventrally and posteriorly with the quadrate and hyomandibular respectively. The symplectic cartilage joins the bone postero-ventrally.

The *mesopterygoid*, *ectopterygoid* and *palatine* (Fig. 11) are loosely connected to the metapterygoid by means of ligaments. The *mesopterygoid* is flat and square-shaped with a prominent projection from the postero-medial corner. This bone is closely sutured with the smaller flat *ectopterygoid* to form a single unit which is closely attached (ligamentously) to the posterior portion of the palatine. The *palatine* is rod-like, the anterior portion thick and stout and the posterior section narrow and cylindrical. Midway along its length on the dorsal side there is a prominent saddle-like articulation facet for the lateral ethmoid. A cartilage pad extends from each extremity, with the large anterior pad articulating directly with the maxilla.



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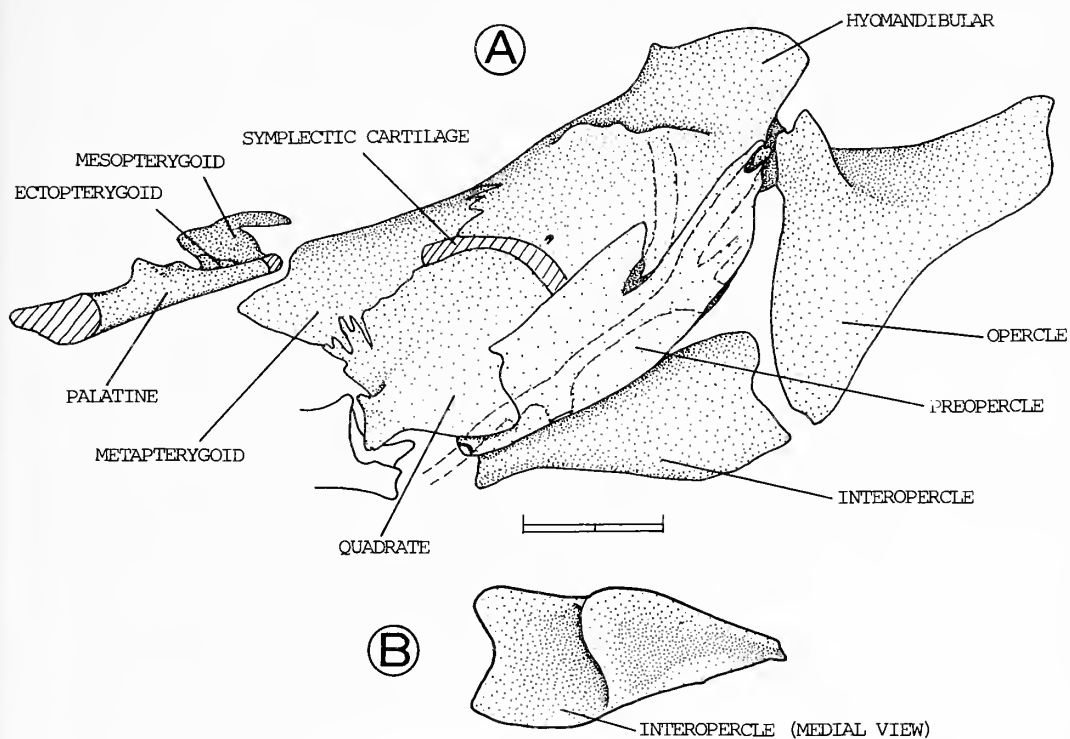


Fig. 10. A. Lateral view of left suspensorium of *Gephyroglanis barnardi* sp. nov. B. Medial view of interopercle. Scale bar = 2 mm.

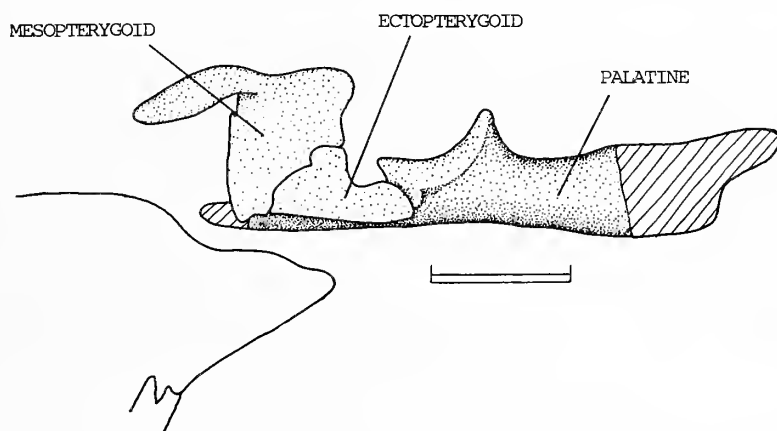


Fig. 11. Medial view of mesopterygoid, ectopterygoid and palatine of *Gephyroglanis barnardi* sp. nov. Scale bar = 1 mm.

Fig. 12. Left maxilla of *Gephyroglanis barnardi* sp. nov., ventral view. Scale bar = 1 mm.

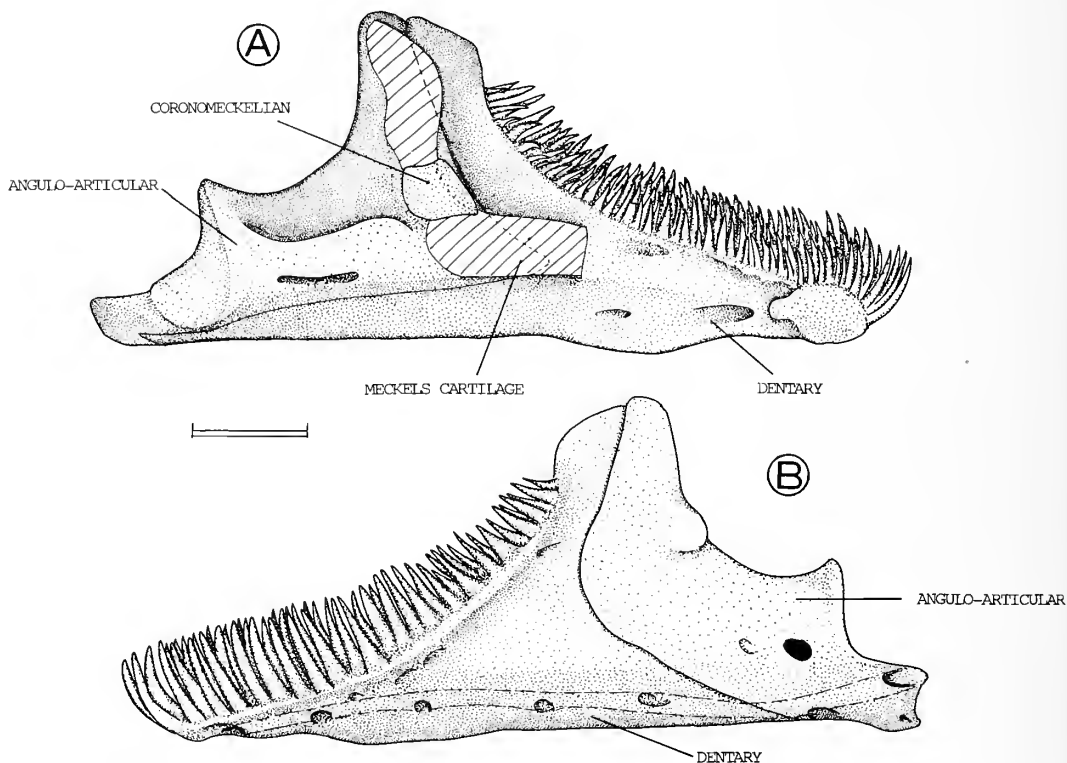
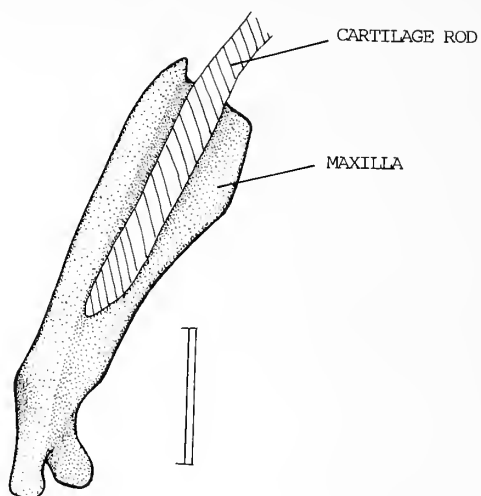


Fig. 13. Left lower jaw of *Gephyroglanis barnardi* sp. nov. A. medial view; B. lateral view. Scale bar = 1 mm.

The *maxilla* (Fig. 12) is a stout compressed rod articulating proximally with the palatine cartilage. A constriction precedes the dual ridged articulation head. A cartilage rod supporting the maxillary barbel extends from a groove on the antero-ventral side.

*Opercular series* (Fig. 10a)

As in all catfish there are no subopercles. The opercle is a slender triangular bone articulating, at the apex, with the hyomandibular by means of a ball and socket articulation. The paddle-shaped *interopercle* is hollow medially with a transverse division forming a facet for the abutment of the postero-lateral edge of the posterohyal. In front of the facet, an elongated groove accommodates the large ligament joining the posterohyal to the angulo-articular.

*Lower jaw* (Fig. 13)

This consists of three bones, the *angulo-articular*, the *dentary* and the *coronomecklian* as well as Meckel's cartilage. The triangular *dentary* is gently curved and bears slender, curved teeth in a broad band from two to seven or eight teeth wide. The mandibular lateral line canal passes along the ventral side of the dentary and has four intermediate pores. A hollow on the postero-medial aspect of the dentary accommodates the angulo-articular and Meckel's cartilage.

Posteriorly the *angulo-articular* is stout and large supporting a large saddle-like articulation facet. Anteriorly the bone is compressed and projects dorsally to form the posterior section of the ascending process of the jaw. A rounded projection (boss) on the postero-lateral edge of the dorsal limb provides an attachment point for the adductor mandibulae muscle. There is a large medio-dorsal excavation in front of the articulation facet. The lateral line canal passes obliquely through the postero-lateral part of the angulo-articular with a single intermediate pore. Meckel's cartilage extends anteriorly to meet the dentary and also forms a dorsal branch which lies in a medial groove on the dorsal limb of the angulo-articular.

The *coronomeckelian* lies medial to the dentary and angulo-articular and wraps around the dorsal limb of Meckel's cartilage.

*Hyoid arch* (Figs 14 and 15)

A small irregularly spherical *interhyal* is present above the triangular posterohyal.

The postero-lateral extremities of the *posterohyal* forms a rounded condyle which articulates in ball and socket fashion within the facet on the interopercle (similar to that described for *G. gilli* and *G. sclateri* by Petrick, 1973). A large ligament attaches to the anterior surface of this condyle and joins the posterior edge of the angulo-articular.

Posteriorly the *anterohyal* is deep and laterally compressed and sutures to the posterohyal. Its anterior end is triangular in transverse section where it is sutured with the relatively large ventrohyal and the smaller dorsohyal.

The *ventrohyal* has a stout triangular lateral portion which sutures to the anterohyal. Medially the ventrohyal is depressed and forms a condyle which articulates both the urohyal and also its opposite fellow. Posteriorly the ventrohyal sutures with the dorsohyal. The smaller *dorsohyal* is a depressed rectangular bone joined laterally with the anterohyal and anteriorly with the ventrohyal (absent from the illustrated individual).

There are usually six *branchiostegal* rays on each arch, five articulating with the anterohyal and one with the posterohyal. The first three or four curved acinaciform rays increase progressively in size posteriorly. Each has a Y-shaped head which articulates on the ventral edge of the anterohyal. The fifth and sixth branchiostegals are spathiform, the fifth articulates on the postero-ventral angle of the anterohyal and the sixth on the antero-ventral angle of the posterohyal.

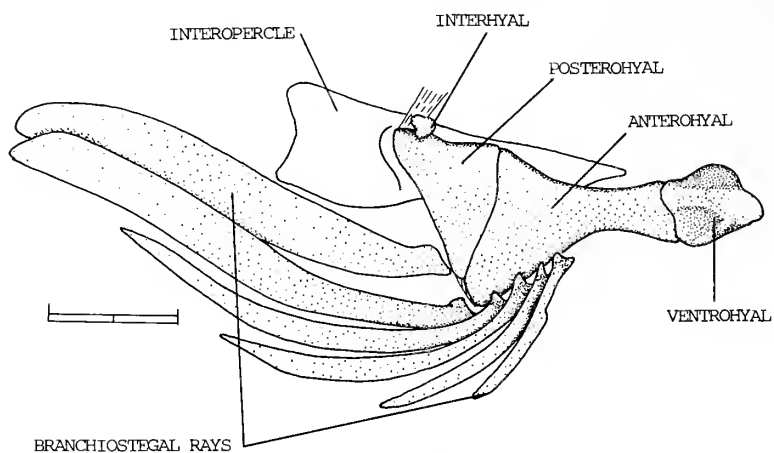


Fig. 14. Medial view of left hyoid arch of *Gephyroglanis barnardi* sp. nov. (dorsohyal absent). Scale bar = 2 mm.

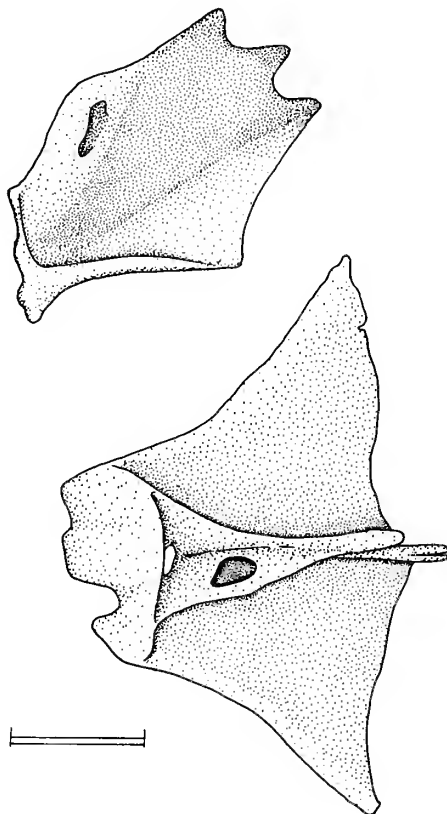


Fig. 15. Lateral view (above) and dorsal view (below) of the urohyal of *Gephyroglanis barnardi* sp. nov. Scale bar = 1 mm.

The *urohyal* (Fig. 15) is a short triangular bone truncated posteriorly with a median dorsal flange. The flange divides anteriorly on the dorsal side to form an articulation bracket for the leading basihyal cartilage. The bracket is flanked anteriorly on each side by an attachment surface for a ligament connecting to the ventral side of either ventrohyal. A median canal passes ventrad behind the attachment surface.

*Branchial Skeleton (Figs 16a, b, c)*

As the interpretation and homology of the siluroid branchial skeleton does not appear to be satisfactorily determined, nomenclature and interpretation of Nelson (1969) will be followed.

There are three *infrapharyngobranchials* on each side. The first is a small slender sliver of bone, sometimes absent, lying anterior to the first epibranchial. The second is entirely cartilagenous and lies at the head of the first epibranchial between the latter and the third infrapharyngobranchial. The third infrapharyngobranchial is elongate and club-like with the broader end posteriorly abutting the fourth upper toothplate.

There are two *upper toothplates*—here termed the fourth and fifth after Nelson (1969)—the fourth is a short club-like bone, edentulous, suspending on its ventral side the large oval fifth upper toothplate. The ventral side of the fifth toothplate is entirely toothed with long slender caniniform teeth (Fig. 16c).

There are five *epibranchials*. The first epibranchial is the largest and has a rod-like medial section extending laterally into a longer dorsoventrally compressed portion. There are three or four long gill rakers along the outer anterior edge. There is a short cartilage pad at each end of the bone. The second epibranchial is similar though slightly smaller than the first. The medial extremities of these two epibranchials lie close together and abut the cartilagenous second infrapharyngobranchial. The third epibranchial is a shorter more slender bone with a prominent dorsal process on the mid-posterior side. The epibranchial joins between the third infrapharyngobranchial and the fourth upper toothplate. The fourth epibranchial is shorter than the preceding three but is less rod-like and forms a low triangular posterior flange. The fifth epibranchial is represented by a small but distinct cartilage rod extending off the posterior edge of the fourth ceratobranchial.

There are five *ceratobranchials* the anterior three of which are relatively simple arched struts, grooved to form a trough on the ventral side and having short cartilagenous extremities. Each successive bone is progressively shorter than the previous one. The fourth ceratobranchial differs in that the medial extremity turns anterad and forms an enlarged cartilage pad. The fifth ceratobranchials are expanded posteriorly to form a dentigerous surface. Their extremities consist of short cartilage pads. The teeth on the fifth ceratobranchials are slender, curved and caniniform.

There are three pairs of *hypobranchials* of which the anterior two are ossified and the third entirely cartilagenous. The bony hypobranchials are dorso-ventrally compressed, broader laterally and more slender medially. The extremities are in all cases cartilagenous. The third hypobranchials are stout cartilage bars against which on the posterior edge the third and fourth ceratobranchials as well as the cartilagenous posterior basibranchial copula articulate.

The *basibranchials* are represented by an anterior series of closely connected cartilage and bony units (representing basibranchials 1–3) and an independent cartilage copula posteriorly. The anterior series consists of a cartilage pad backed with a bony section, a second cartilage pad and bone which passes ventral to the third hypobranchial cartilages and itself ends in the form of a small cartilage. The posterior hypobranchial forms a large rectangular cartilage pad articulating anteriorly with the third hypobranchials, posteriorly with the fifth ceratobranchials and laterally with the medial cartilages of the fourth ceratobranchials.

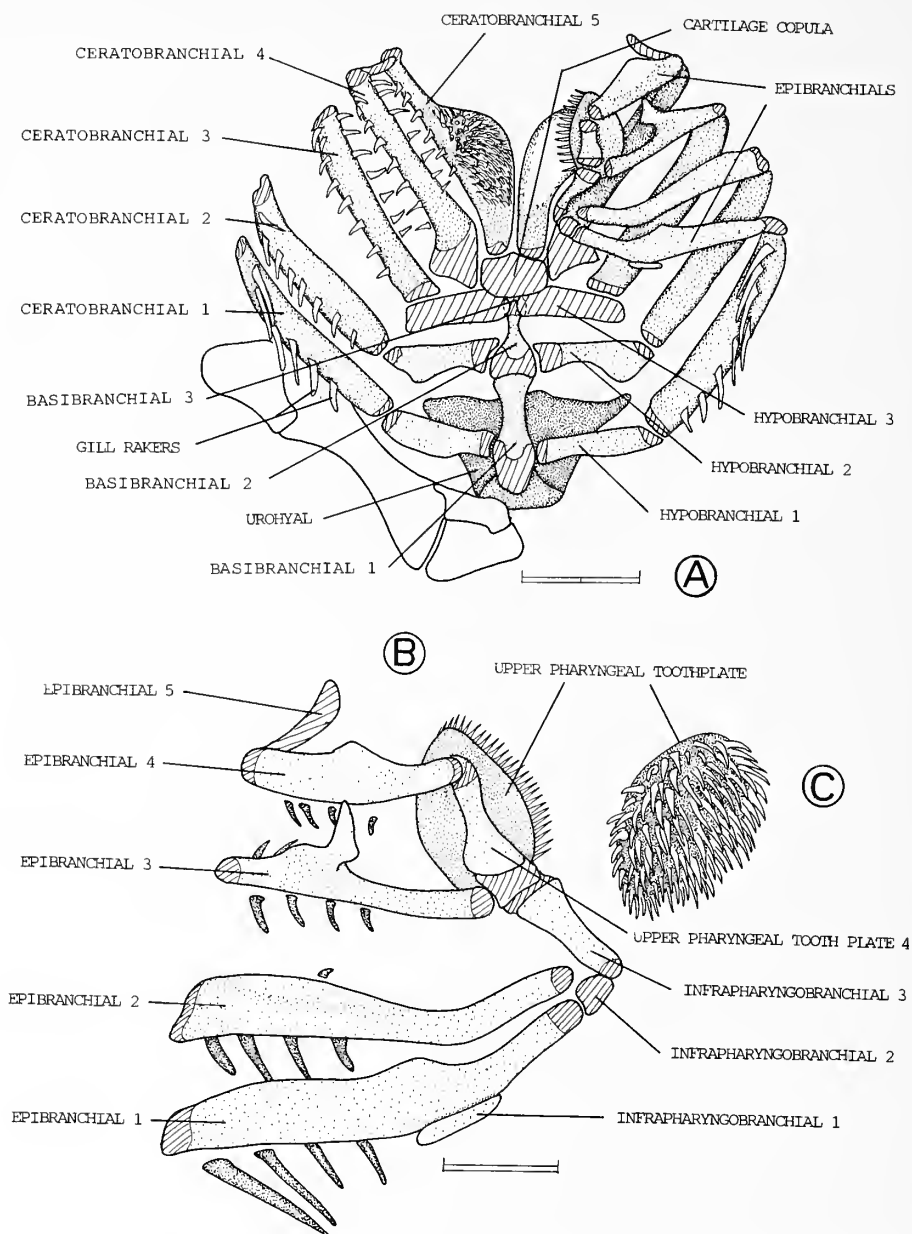


Fig. 16. A. Dorsal view of the branchial skeleton of *Gephyroglanis barnardi* sp. nov. with right epibranchials, infra-pharyngobranchials and upper tooth plates removed. Left gill rakers only depicted on 1st cerato-branchial. Scale bar = 2 mm.

B. Dorsal view of right epibranchials, infra-pharyngobranchials and upper tooth plates. Scale bar = 1 mm.

C. Ventral view of right upper tooth plate, same scale as B.

There are six to nine simple *gill rakers* along the anterior edges of all ceratobranchials and three to four similar rakers along the anterior edges of the epibranchials (except the fifth). There are no gill rakers along the posterior edges of the first, second and fifth ceratobranchials or the first, and fifth epibranchials. A single small gill raker is irregularly present on the posterior edge of the second epibranchial.

*Pectoral girdle (Figs 17a, b, c)*

The pectoral girdle on each side consists of the supracleithrum, cleithrum, mesocoracoid, coracoid and radials. The supracleithrum has already been described (see above). The *cleithrum* is the largest single element in the girdle and unites medially in a symphysis with its opposite member. The dorsal limb of the cleithrum terminates in a stout peg which articulates within the socket of the supracleithrum. There is a short and relatively broad posterior humeral process at the base of the dorsal limb. The ventral limb is directed medially and forms a broad flat plate. The cleithrum folds over latero-ventrally to form a thick lip which partly encloses a deep ventral groove in which the base of the pectoral spine articulates.

The *coracoid* is a large complex bone sutured postero-medially to the cleithrum and articulating by means of a well developed interdigitating junction with its opposite member. On the ventral side of the girdle the coracoid forms a bridge over the cleithral groove and sutures on the thick overfolded lip. An articulation condyle for the pectoral spine is formed at the posterior base of the bridge. On the antero-ventral side of the coracoid forms a narrow ridge or flange which decreases in altitude to disappear medially.

The *mesocoracoid* is represented by a thin strut which runs from the posterior end of the ventral coracoid ridge to the posterior edge of the coracoid. A notch on the posterior side of the base of the strut forms an articulation facet for the median radial. A foramen on the coracoid above the base of the mesocoracoid allows for the movement of the head of the pectoral spine.

There are three proximal *radials* and two smaller distal ones. The first proximal radial is a large trapezoidal cartilage located posterior to the base of the pectoral spine. This assists in the articulation of the pectoral spine as well as of the following two rays. The second and third proximal radials are rod-like bones connecting the posterior four rays with the coracoid. The two small secondary or distal cartilage radials occur between the first and second proximal radials and the fin rays.

*Weberian apparatus (Figs 18a, b, c, d)*

The complexities of the siluroid Weberian apparatus have been described by several authors, most notably by Chardon (1968). The fusions and modifications are such that the individual components are not readily recognizable and the present description aims solely to provide a comparative base for *G. barnardi*.

The first vertebra is represented by the centrum only, and this is compressed to a thin plate. The second to fourth vertebrae are indistinguishably fused and joined by an elaborately interdigitating suture to the fifth vertebra to form a single complex. A complex shield is developed above the centra of these vertebrae and has on each side a large bony strut (the anterior branch of the parapophyses of the fourth vertebra) which extends antero-laterally and is firmly bound to the ventral limb of the posttemporal. The posterior branch of the fourth parapophyses form slender projections from the shield. On the dorsal side a strong V-shaped strut (fourth neural spine) emerges, forms the neural arch and sutures with the third proximal pterygiophore of the dorsal fin. On the ventral side of the complex there is a well developed aortal groove which extends posteriad over the fifth and subsequent precaudal vertebrae.

The parapophyses of the fifth vertebra form prominent projections dorso-laterally. The enlarged proximal pterygiophore of the second dorsal spine lodges within a pit on the dorsal side of the fifth vertebra. The sixth vertebra is the first to carry pleural ribs. Like the fifth

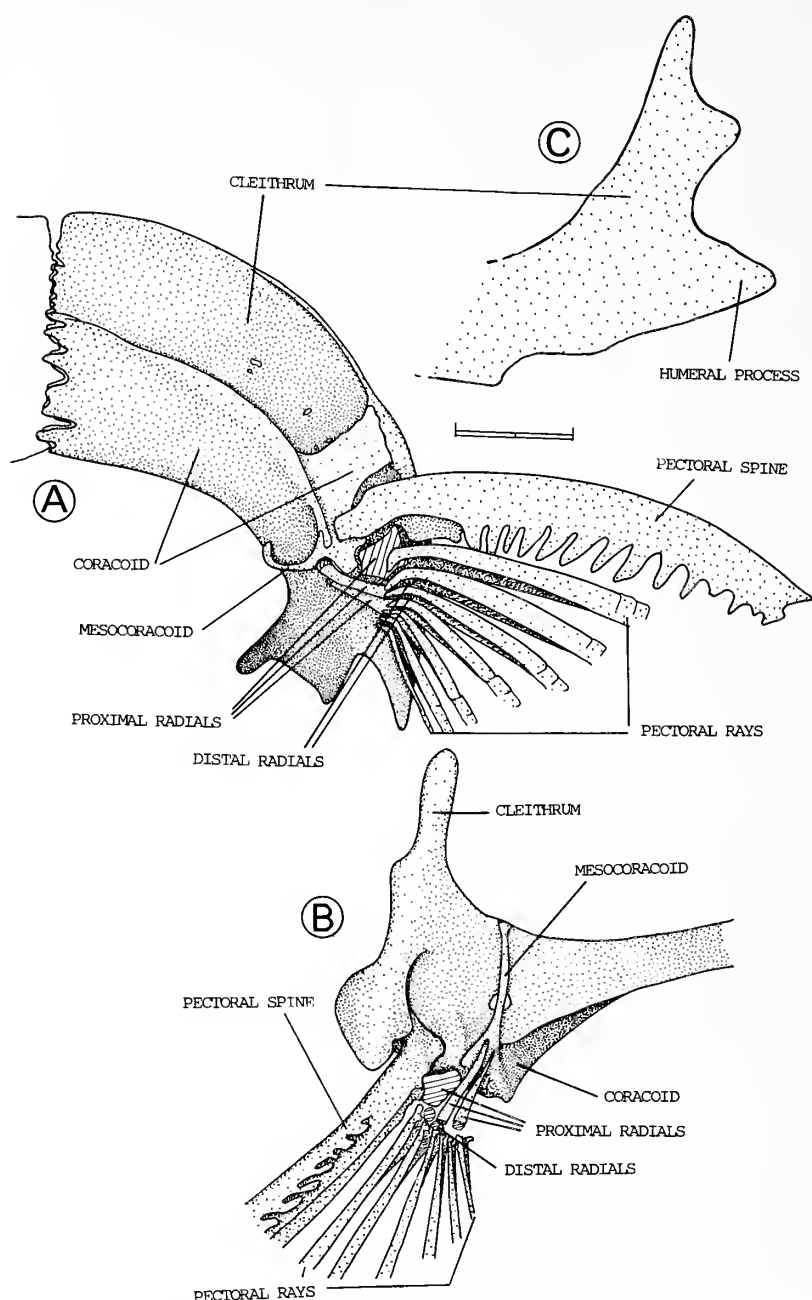


Fig. 17. A. Ventral view and B. posterior view of left pectoral girdle of *Gephyroglanis barnardi* sp. nov. C. Lateral profile of cleithrum of *Gephyroglanis barnardi* sp. nov. Scale bar = 2 mm.



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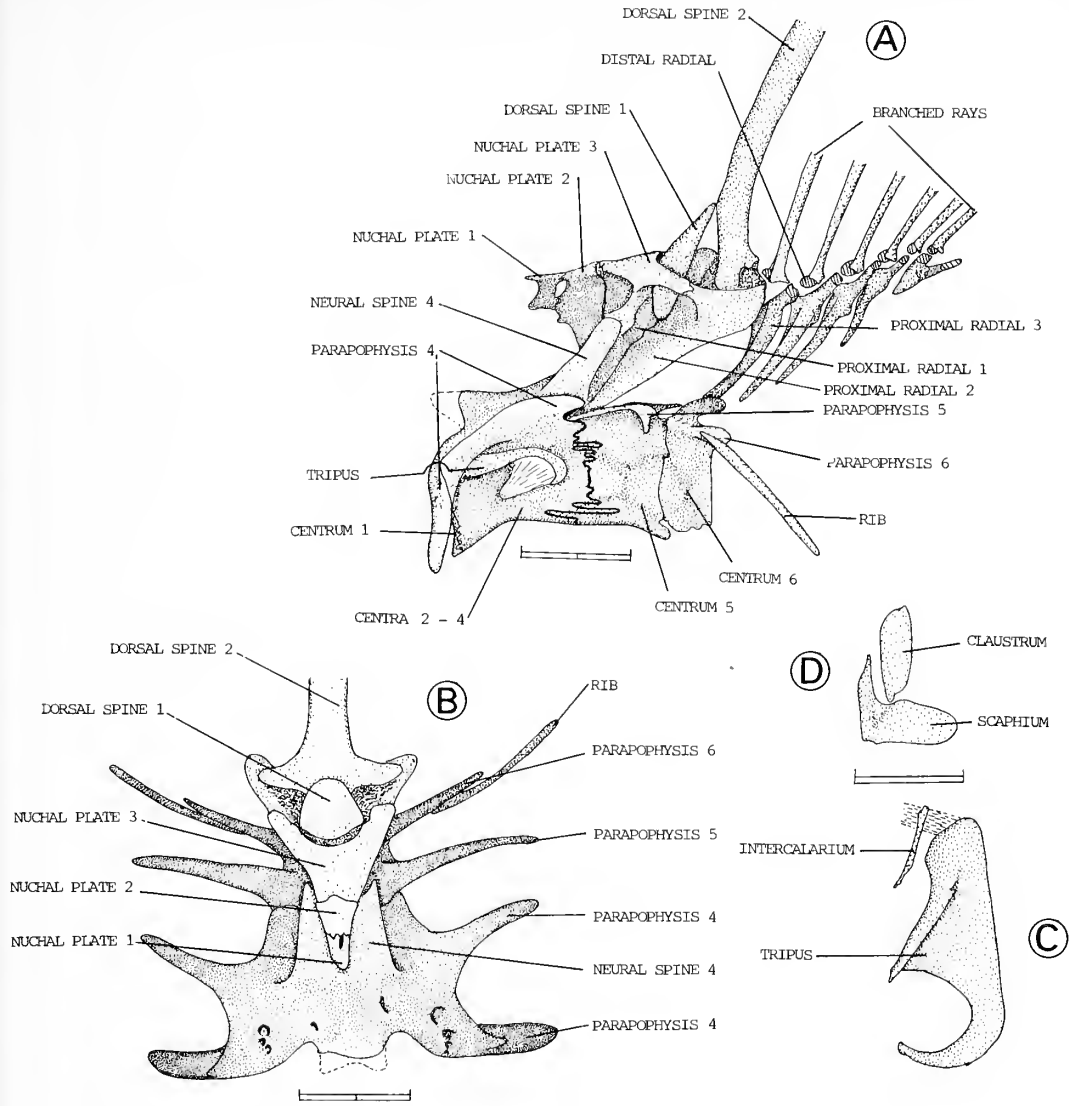


Fig. 18. A. Lateral view and B. dorsal view of Weberian vertebrae and dorsal fin skeleton of *Gephyroglanis barnardi* sp. nov. Scale bar = 2 mm. C. Dorsal view of right tripus and intercalarium and D. lateral view of right scaphium and claustrum of *Gephyroglanis barnardi* sp. nov. C & D Scale bar = 1 mm.

vertebra the parapophyses of the sixth are well developed as dorso-lateral projections. The pleural ribs are connected to the antero-ventral edge of the projections. The neural arches of this vertebra are short and directed posteriad, uniting behind the fifth proximal pterygiophore. The fifth pterygiophore is thus held within a receptacle bounded anteriorly by the neural arches of the fifth vertebra and laterally and posteriorly by the neural arches of the sixth vertebra.

The *tripus* is attached to a bony flange beneath the dorsal shield of the anterior vertebral complex. The tripus itself is elongate, and thin with a flat postero-medial projection and a tapering lunate transformator process. Anteriorly the tripus is linked to the slender rod-like *intercalarium*.

The *scaphium* lodged within a notch in the exoccipital is in turn connected by means of a short ligament to the intercalarium. It is an L-shaped bone with the horizontal limb broader and larger than the vertical limb. The simple leaf-like *claustrum* lies within the angle of the scaphium.

#### *Precaudal vertebrae*

The neural arches of the seventh and eighth vertebrae form a broad groove which accommodates the dorsal fin pterygiophores. The neural spines of the ninth and subsequent vertebrae become progressively longer and reach a maximum at about the fifteenth or sixteenth vertebra. The parapophyses of the precaudal vertebrae likewise progressively decrease in size. The development of a closed haemal arch at about the twelfth vertebra precedes the disappearance of distinct parapophyses and the formation of a haemal spine at about the fifteenth vertebra. In consequence there are several vertebrae with a closed haemal arch, parapophyses and attached pleural ribs.

#### *Caudal vertebrae (see Fig. 19)*

The caudal vertebrae are, apart from the first few with non-united parapophyses and short haemal spines, reasonably uniform in character. They all have well developed neural and haemal spines, pre- and post-neurapophyses and the majority have pre- and post-haemapophyses. Three or four preural vertebrae lack post-haemapophyses and their pre- and post-neurapophyses merge with the neural arch.

#### *Caudal skeleton (Fig. 19)*

The caudal skeleton is characterized by the near complete fusion of the hypurals into two hypural plates. The compound ural centrum ( $Pu_1 + U_1$ ) is fused with the parhypural and hypurals 1 and 2 as well as the uroneurals 1 and 2 to form a single unit. Weak suture lines between the hypurals 1 and 2 and the parhypural are still evident. Hypurals 3 to 6 are also fused into a single plate although here only a single suture line is still evident. A well developed hypurapophysis on the base of the parhypural is joined to a secondary hypurapophysis on the base of hypural 1 (i.e. type A hypurapophysis of Lundberg and Baskin, 1969).

A small cartilagenous third uroneural is present between the first dorsal principal caudal ray and the last dorsal procurent ray. There is a single epural. Procurent rays vary between 15 and 18 (Table 4) with three of the six cleared specimens having 16 dorsal and 17 ventral procurent rays.

#### *Dorsal fin skeleton (Figs 18a and b, 20)*

The first nuchal plate is small and triangular and is fused to a median plate or flange derived, according to Alexander (1966), from a supraneural bone. This compound unit is sutured posteriorly to a second slightly larger but essentially similar nuchal plate. This in turn is fused to a third larger Y-shaped nuchal plate and the proximal radial of the first pterygiophore. This radial has bilateral transverse flanges which suture with the dorsal V-shaped projection of

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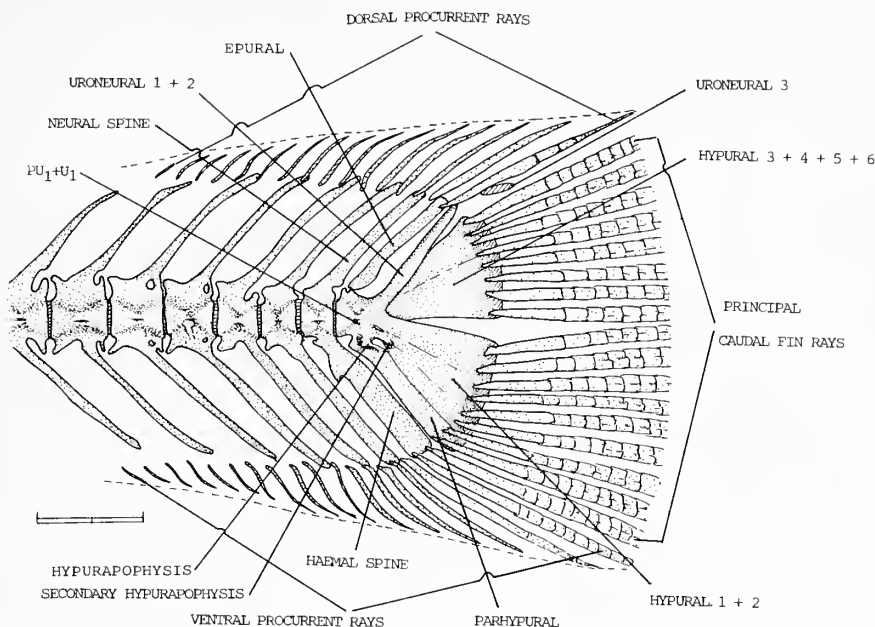


Fig. 19. Lateral view of caudal fin skeleton of *Gephyroglanis barnardi* sp. nov. Scale bar = 2 mm.

the fourth neural spine. The postero-dorsal portion of the first radial is thickened and knob-like and is straddled anteriorly by the first spine. A large proximal radial of the second pterygiophore lodges within a pit on the dorsal side of the fifth vertebra and sutures anteriorly with the first proximal radial. The dorsal surface is roughened and expanded to form a friction pad for the base of the second dorsal fin spine. A median dorsal projection forms a ring of bone which passes through a foramen on the large (second) dorsal spine (Fig. 20).

The proximal radial of the third pterygiophore is reduced in size relative to the first and second and forms a narrow strut supported basally by the sixth vertebra. Its cartilagenous dorsal extremity articulates with the cartilage distal radial of the second branched ray. There are four subsequent pterygiophores; each is progressively reduced in size and shares the support of two branched rays. The proximal radial of the last pterygiophore is biramous and supports the last branched ray. A cartilage distal radial is present between the divided base of each branched ray and the cartilagenous head of each proximal radial.

## *Pelvic fin skeleton (Fig. 21)*

Each pelvic bone is forked antero-laterally and has a broad medial plate which meets and forms a cartilagenous symphysis with the opposite unit. A slender cartilagenous ischial process is present. The fin rays articulate against a cartilage-capped posterior ridge. A short lateral splint, similar to that described by Gosline (1961) for many lower teleostean fishes, lies adjacent to the first ray.

## *Anal fin skeleton*

Apart from the first, the proximal radials of the anal fin are all simple and slender. The first proximal radial is a short heart-shaped plate providing an attachment surface for the bi-

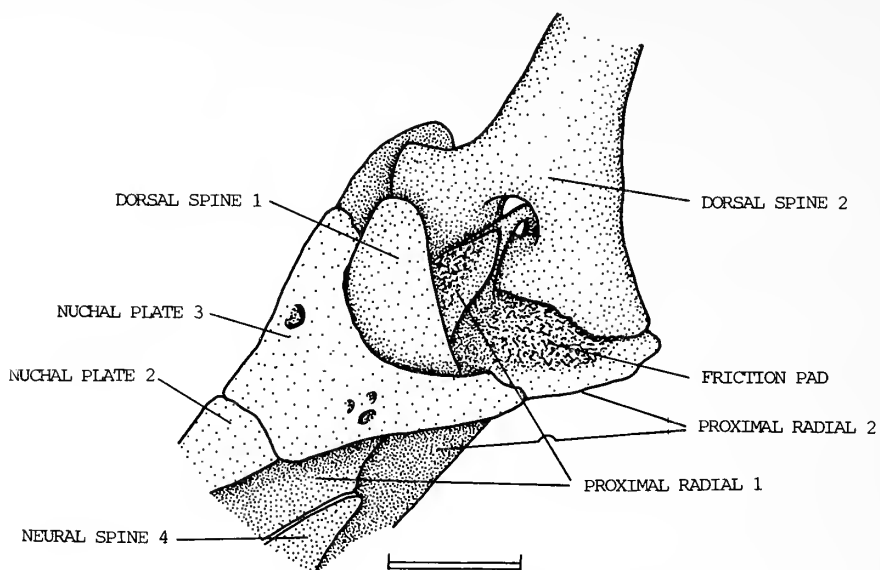


Fig. 20. Antero-dorso-lateral view of portion of dorsal fin skeleton of *Gephyroglanis barnardi* sp. nov. A ligament between dorsal spine 1 and 2 has been cut and the spines are separated more than is natural. Scale bar = 1 mm.

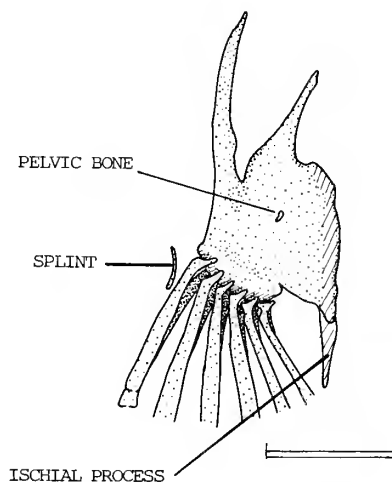


Fig 21. Dorsal view of left pelvic fin skeleton of *Gephyroglanis barnardi* sp. nov. Scale bar = 1 mm.

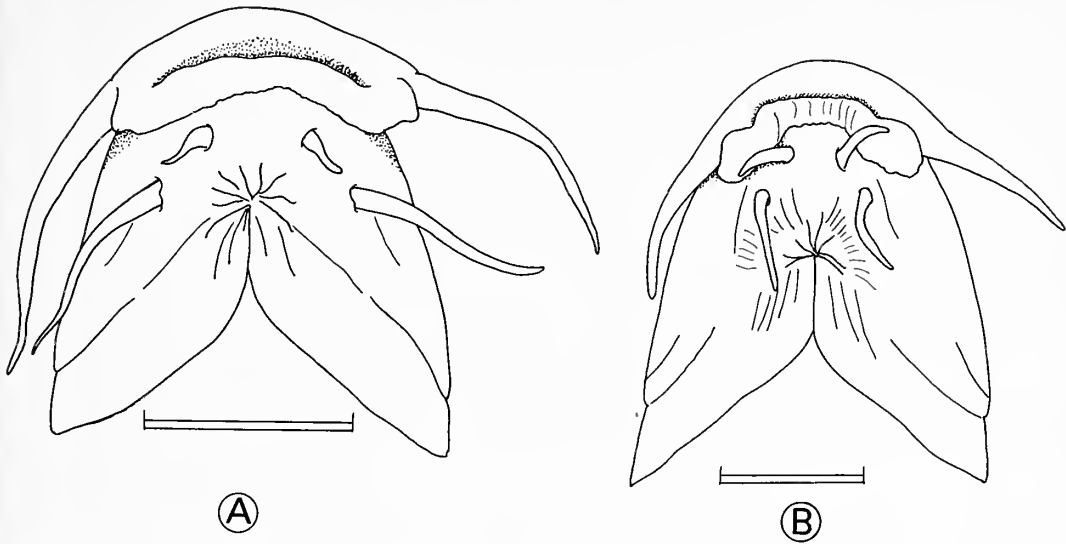


Fig. 22. Ventral view of head of A. *Gephyroglanis gilli* (AM/P 7646, 61 mm SL) and B. *Gephyroglanis sclateri* (AM/P 7840, 62 mm SL). Scale bar = 5 mm.

lateral blocks of the infracarinalis medius muscle running from the pelvic bones. The articulation end of each proximal pterygiophore terminates in a pad of cartilage. These pads articulate with cartilage spheres (the distal radials) located between the base of each fin ray. The unbranched fin rays are slender and flexible; only the small anterior-most two are unsegmented and none can be described as spinous. On account of the minute size of the first ray, accurate counts are not possible without clearing and staining. The branched rays are quadrifurcate except the anterior and posterior rays which are trifurcate.

#### DISCUSSION

There is little doubt on the morphological evidence presented above that there are two distinct *Gephyroglanis* species in the Olifants River system. A surprising outcome of the investigation is that Barnard, whilst fully aware of the two forms within his Olifants samples, did not perceive the real extent of the differences between them. Barnard's entire attention focused on the form of the fins, structures which are well known to be phenotypically influenced by the environment (Hubbs, 1941).

In addition to the array of anatomical characters on which the existence of the new species, *G. barnardi*, is recognized, the suggestion by Barnard (1943) that the two forms have different habitat preferences was tested in the field. Barnard (1943) indicated that the low fin form (= *G. barnardi*) preferred a sluggish muddy environment and the high fin form (*G. gilli*) preferred a stony swiftly flowing habitat. On a visit to the Noordhoeks River in January 1981 the author and Mr S. Thorne electrofished both species from the same stony bottomed, swiftly flowing stretch of river. Both species were taken from a site in the Thee River which, whilst rocky bottomed, had been obstructed by means of a rocky wall so that the current was sluggish and the rocks were covered by a layer of silt. In a third tributary, the Oudste River, at a site where the current was sluggish and the bottom was a mosaic of bedrock, scattered loose rocks, sand and mud and where the banks were undercut in a fine grained soil only *G. gilli* was

encountered. Similarly in the Boskloof River, a tributary of the Boontjies River, where the rocky bottom was covered by silt, only *G. gilli* was collected. In both the Boskloof and the Oudste localities *G. gilli* was taken both from amongst the rocks and from under the muddy banks.

It appears, therefore, that the correlation of fin form to habitat reported by Barnard (1943) is not upheld. In this regard it is interesting that seven specimens taken from an irrigation channel off the Jan Diessels River (SAM 22467) and reported by Barnard (1943) as being of the low fin form are in fact specimens of the high fin form recognized as *G. gilli*. The only low fin forms (*G. barnardi*) within the type series of *G. gilli* are seven specimens in SAM 19359 collected in February 1939 from the Noordhoeks River and the Olifants River at Keerom. These facts contradict Barnard (1943: 229) and it appears that either the samples were mixed up after collecting or that Barnard was confused in correlating specimens and localities. In the light of more recent collecting and observations as reported in the previous paragraph the latter explanation is the more likely. Furthermore, the author collected only *G. gilli* in the Jan Diessels River in January 1973.

A lectotype for *G. gilli* (SAM 29231) has been selected from SAM 22467 which is part of the original syntype series (of this species). The remaining specimens of the sample become paralectotypes as does the remainder of SAM 19359 after the removal of seven *G. barnardi* specimens. The seven *G. barnardi* specimens (SAM 29232) have been included as paratypes of the species. All the material of *G. gilli* and *G. sclateri* examined is recorded in Appendix 1.

The three southern African *Gephyroglanis* species (*G. barnardi*, *G. gilli* and *G. sclateri*) are geographically remotely isolated from other species of this genus. The key character on which Boulenger (1901) originally placed *G. sclateri* within *Gephyroglanis* is the absence of teeth on the palate (vomer). As pointed out by Roberts (1975) a loss character such as this is not necessarily synomorph and could easily (and possibly more likely) be a convergent or parallel development in such geographically remote species. Petric (1973; 1976) suggested that the manner in which the posterohyal articulated with the interopercle and the concomitant loss of the interhyal in *G. gilli* and *G. sclateri* was an unusual feature of these South African species. If this is so (the phenomenon does not appear to have been reported for other bagrid species) it would strongly suggest a synapomorphy and indicate at least that the southern species are monophyletic. Personal observations in the osteology of *G. gilli* and *G. sclateri* in the course of the present investigation have revealed that the interhyal is frequently present in both species, albeit in a vestigial form. The synapomorphy *per se* is not therefore negated which suggests that the generic identity of the South African *Gephyroglanis* species is open to question. The type series of this genus is *G. congicus* Boulenger, 1899, which inhabits the Zaire River.

In recording the above it should also be noted that the South African *Gephyroglanis* do not agree with all of Jayaram's (1966) points of definition of this genus. Firstly that author describes the snout as acuminate (narrow and pointed), however, the snouts of *G. gilli* and *G. barnardi* are rather obtusely blunt and rounded. Furthermore, although the snout of *G. sclateri*, a species examined by Jayaram, is more slender than that of *G. gilli* and *G. barnardi* it cannot be described as acuminate. Secondly the lips are recorded as thin and plain, however, they are papillose in *G. barnardi* and *G. gilli* and rugose in *G. sclateri*. The number of branchiostegal rays is smaller in the South African species than recorded for the genus by Jayaram (*viz* eight to ten); *G. sclateri* and *G. gilli* usually have seven on either side and *G. barnardi* six. Further research on the generic status of the South African species is in progress, and no change is made at this stage pending the outcome of the investigation.

The absence of gill rakers on the posterior border of the first and second gill arches is a difficult character to evaluate without more in- and out- group comparisons. The only reference to this character which has been traced in the literature is Harry (1935). In describing the

osteology of *Amphilius longirostris* (Boulenger, 1901) Harry (*op. cit.*: 216) recorded that there were gill rakers on the first four gill arches (ceratobranchials) and "In addition the third and fourth ceratobranchials bear a single row of eight stout spinous rakers on the inner face". Petrick (1976) did not record the gill-rakers of *G. sclateri* in his account of the osteology of the species. In both *G. sclateri* and in *G. gilli* the situation with regard to the absence of rakers on the posterior edge of the first two arches is, however, the same as that described above for *G. barnardi*. In addition to some amphiliids [Harry, 1953; pers. obs. on *Amphilius platyichir* (Günther, 1864), *A. natalensis* Boulenger, 1917 and *A. lampei* Pietschmann, 1913], the mocho-kids *Synodontis leopardinus* Pellegrin, 1914 and *Chiloglanis anoterus* Crass, 1960, also do not have posterior edge rakers on the first two arches (pers. obs.). The situation in other bagrids is evidently variable as *Chrysichthys hildae* Bell-Cross, 1973 and *Auchenoglanis ngamensis* Boulenger, 1911 have stout rakers on the posterior edge of the first four gill arches. *Gephyroglanis longipinnis* Boulenger, 1899 (MRAC 123287-288) has rows of knob-like rakers on the posterior edges of all the gill arches. *Gephyroglanis congicus* (MRAC 96639) has an equally elaborate series of branched rakers on the posterior edges of the gill arches. A complex distribution of the character is foreseen within the siluriformes which is likely to be closely correlated with functional demands.

A few preliminary comments on the inter-relationships of the three South African species can be made at this stage. Generally *G. barnardi* differs more from both *G. gilli* and *G. sclateri* than these two species do from each other, which is not in itself any indication of the phylogenetic relationships between them. Many of the distinguishing features of *G. barnardi* are apparently autapomorph: for example the relatively weak dorsal and pectoral fin spines; the small humeral process; the reduction in size of the nuchal shield and its connection with the supraoccipital.

The caudal fin skeleton possibly provides one synapomorphy for *G. barnardi* and *G. gilli* in that these two species have a greater degree of hypural consolidation than does *G. sclateri*. In *G. sclateri* the hypurals are generally free except for hypurals three and four which are fused basally. In *G. barnardi* and *G. gilli* hypurals one and two are fused or separate only in juveniles. In *G. barnardi* hypurals three, four, five and six are also fused. The degree of fusion shown by *G. barnardi* is greater than that shown by any bagrid species reported on by Lundberg and Baskin (1969). A few bagrids including *Gephyroglanis longipinnis* were found by these authors to have hypural three and four fused but only one species (*Chrysichthys ornatus* Boulenger, 1902) to have, in addition, hypurals one and two fused. The skeletal differences relating to the caudal fins of the three South African species are (coincidentally) correlated with the external forms of these fins: in *G. barnardi* the fin is truncate, in *G. gilli* emarginate and in *G. sclateri* forked. Lundberg and Baskin (1969) found that the majority of bagrid species they examined had B type hypurapophyses (the hypurapophysis and secondary hypurapophysis on hypural 1). The South African *Gephyroglanis* species appear to have an A type hypurapophysis. All specimens of *G. sclateri* and *G. barnardi* examined had an A type and of the three available specimens of *G. gilli* two had an A type, however, one had a B type. (A type: hypurapophysis on parhypural arch, secondary hypurapophysis on base of hypural 1).

A feature of the caudal fin skeleton of several catfish examined to date which appears to have been overlooked by Lundberg and Baskin (1969) is the presence of a third uroneural. This element is clearly present in *G. barnardi* albeit as cartilage. Its cartilaginous nature possibly explains why it was not found in other catfish by Lundberg and Baskin (*op. cit.*).

Monod (1968) illustrated the caudal skeleton of a *Gephyroglanis* species and included a cartilage "opistural" which is here interpreted as the third uroneural. This element is also clearly present in cartilage form in the schilbeids, *Schilbe mystus* and *Eutropius depressirostris* (AM/P 3121, 3256 and AM/P 742 respectively). It is difficult to detect in only alizarin red stained specimens, but has been found in both dry and alizarin preparations of *G. sclateri* and *G. gilli* (pers. obs.).

One character which contradicts the caudal fin synapomorphy of *G. barnardi* and *G. gilli* is the dorsal fin ray count. *G. barnardi* has usually six branched dorsal fin rays the number which is most common among other *Gephyroglanis* species (Boulenger, 1911; Jayaram, 1966) and other genera of the Chrysichthyinae (Jayaram, 1966). Based on an out-group comparison this appears to be the plesiomorph condition. *G. gilli* and *G. sclateri* both have seven dorsal branched rays, arguably synapomorph in the South African context. On the other hand it has been pointed out (Heemstra, pers. comm.) that the configuration of the last dorsal proximal radial (Fig. 18a) in *G. barnardi* suggests that the last ray has been lost. If this is so, then the possession of the seven branched dorsal rays of *G. gilli* and *G. sclateri* is the plesiomorph condition and is not indicative of a closer relationship to each other than either may have to *G. barnardi*.

The placement of the mandibular barbels is similar in *G. barnardi* and *G. gilli* but differs in *G. sclateri* (Figs 5;22). In the former two species the posterior mandibular barbels are lateral to the gular node and postero-lateral to the anterior mandibular barbels. In *G. sclateri* the posterior mandibular barbels are distinctly anterior to the gular node and lie more or less posterior to the anterior pair. The vertebral counts of the South African *Gephyroglanis* species are compared in Table 3. There is a broad overlap in counts between *G. gilli* and *G. barnardi*, however, *G. sclateri* has a larger count. This finding agrees with Lindsey's (1975) pleomeristic rule as *G. sclateri* attains twice the size of the other two species.

Jayaram (1966) separated *G. sclateri* and *G. gilli* chiefly on the basis of anal fin rays (*G. gilli* 11–13 v. 16–17 in *G. sclateri*). These figures were based on Boulenger (1901, 1911) and Barnard (1943) with the latter author dividing the rays into spines, simple rays and branched rays. Barnard's (1943) count for *G. sclateri* was 2–4, 2–3, 10–12, usually 4, 2, 12, with the total range 16–19. The count for anal fin rays given by Barnard for *G. gilli* was 2–3, 2, 10–11, most frequently 3, 2, 10, with a total range of 14–16 not 11–16 as given by Jayaram (1966). A comparison of anal fin rays of the three southern African species is given in Table 2. The formula for *G. barnardi* is III–VI, 10–13 (spines and simple rays not separately distinguished), most frequently IV, 11 with a total range of 14–18. *G. sclateri* is therefore generally characterized by more anal fin rays than either Clanwilliam Olifants species although this is not necessarily a diagnostic feature of every specimen. The South African *Gephyroglanis* species have a greater number of anal fin rays than other species of this genus (Jayaram, 1966), a fact which is noteworthy in terms of the general distinction already made of these three remote southern representatives.

The geographical distribution of *Gephyroglanis* species in the Orange and Olifants River systems, together with other freshwater fish species in these two systems, offers substantial support for the theory that the two systems were linked at some stage in the past (Jubb & Farquharson, 1965; Skelton, 1980). Fryer (1977) also suggested such a link on the evidence of the distribution of related species of the ectoparasitic crustacean genus *Chonopeltis*. Two factors suggest that this link is likely to have been a relatively ancient one, probably pre-Pleistocene. These are the high degree of endemic speciation of the fish species concerned in both the Orange and the Olifants, and secondly that there is little direct present day geological indication of such a link.

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APPENDIX 1

Material of *Gephyroglanis gilli* and *G. sclateri* referred to.

*Gephyroglanis gilli*—Olifants River System.

- AM/P 893: K. van Rensburg, March 1965, Noordhoeks and Thee Rivers.  
AM/P 1364: F. L. Farquharson, October 1964, Noordhoeks River.  
AM/P 1369: F. L. Farquharson, April 1967, Noordhoeks River.  
AM/P 1372: 3, F. L. Farquharson, April 1967, Matjies River.  
AM/P 1851: 4, P. H. Skelton and D. Heard, January 1973, Jan Diessels River.  
AM/P 1861: 6, P. H. Skelton, January 1973, Breekkraans River.  
AM/P 1865: 6, P. H. Skelton, February 1973, Noordhoeks River.  
AM/P 1879: 20, K. van Rensburg, March 1965, Noordhoeks River.  
AM/P 2604: 2, P. H. Skelton and D. Heard, January 1973, Jan Diessels River.  
AM/P 7646: 4, K. Hamman, S. Thorne, August 1979, Noordhoeks River.  
AM/P 7673: 3, S. Thorne, G. Gabriel, March 1980, Noordhoeks River.  
AM/P 7677: 2, S. Thorne, G. Gabriel, March 1980, Thee River.  
AM/P 7688: 9, S. Thorne, G. Gabriel, March 1980, Rondegat River.  
AM/P 7690: 4, S. Thorne, G. Gabriel, March 1980, Rondegat River.  
AM/P 7710: 6, S. Thorne, G. Gabriel, March 1980, Noordhoeks River.  
AM/P 8201: 4, P. H. Skelton, S. Thorne, January 1981, Noordhoeks River.  
AM/P 8205: 2, P. H. Skelton, S. Thorne, January 1981, Thee River.  
AM/P 8208: 7, P. H. Skelton, S. Thorne, January 1981, Oudste River.  
AM/P 8211: 3, P. H. Skelton, S. Thorne, January 1981, Boskloof River (trib. Boontjies River).  
SAM 19359: 11, K. H. Barnard, C. W. Thorne, February 1939, Olifants River at Keerom & Noordhoeks River (Paralectotypes).  
SAM 22467: 12, K. H. Barnard, C. W. Thorne, A. C. Harrison, April 1937, Jan Diessels River & Boontjies River (Paralectotypes).  
SAM 22477: 6, K. H. Barnard, April 1949, Thee River.  
SAM 29231: 1, Same as SAM 22467 (Lectotype).

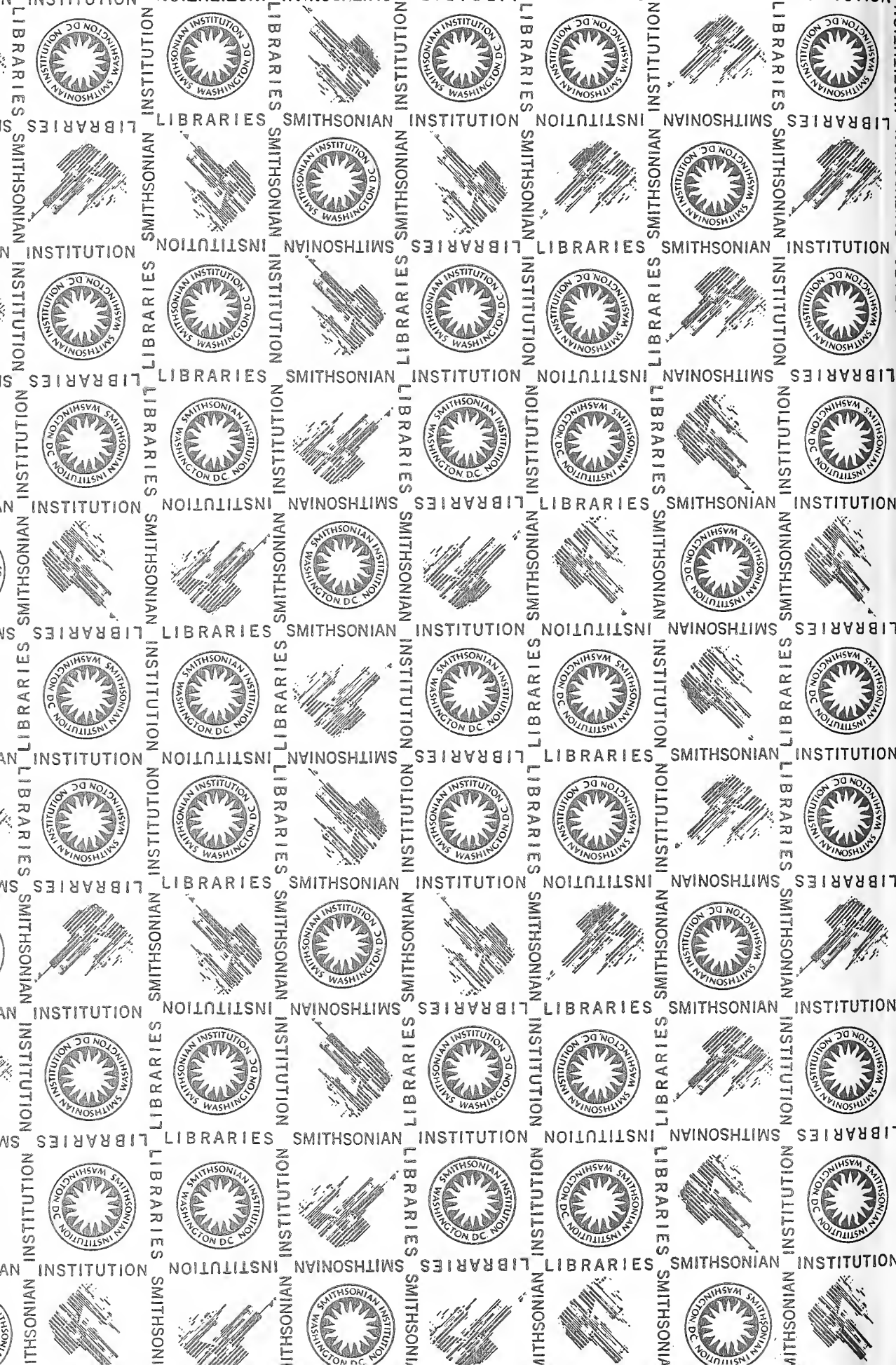
*Gephyroglanis sclateri*—Orange River System

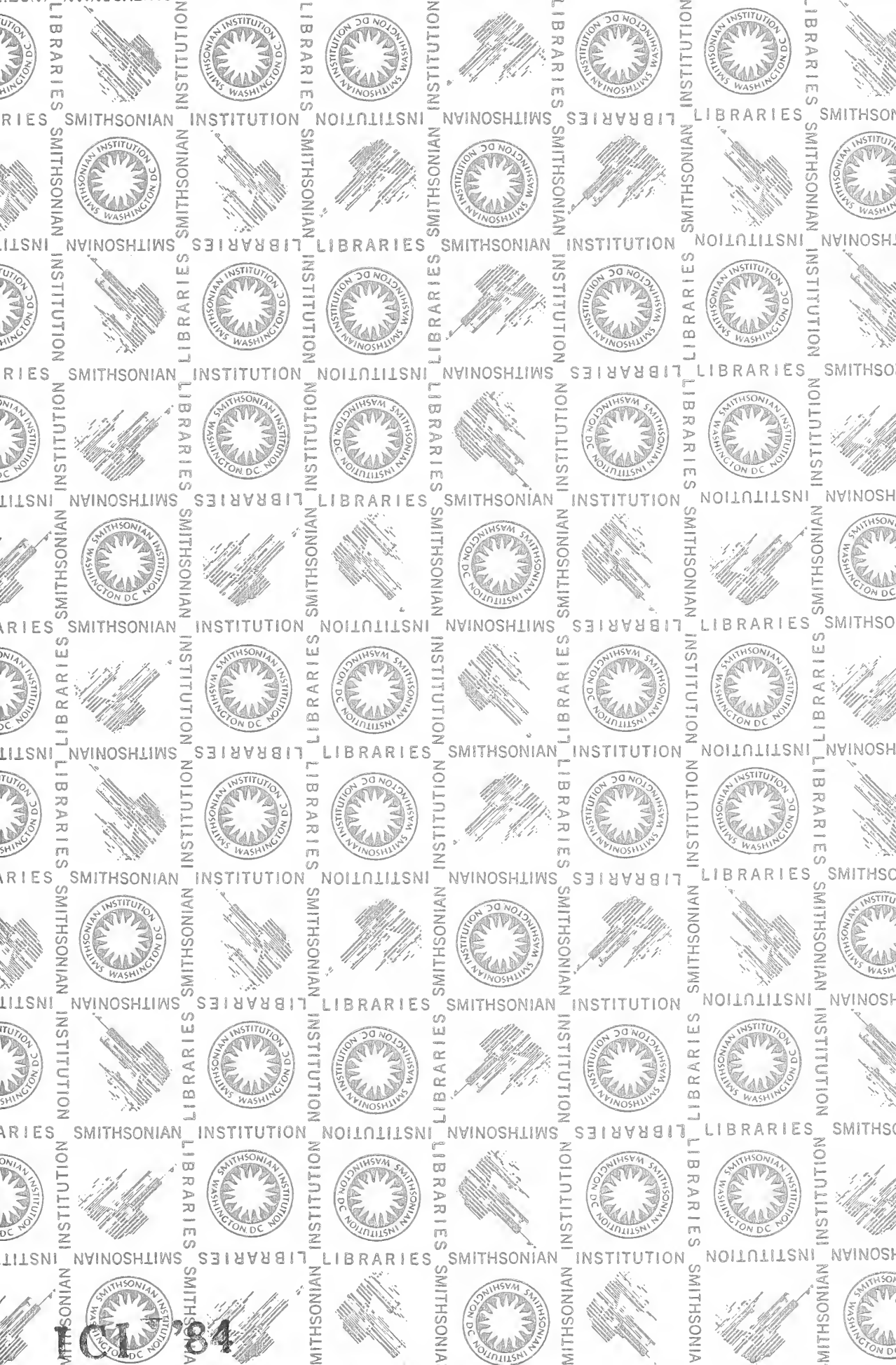
- AM/P 1381: Cape Department of Nature & Environmental Conservation, September 1966, Orange River at Venterstad, Cape Province.  
AM/P 1447: Cape Department of Nature & Environmental Conservation, September 1970, Telle River.  
AM/P 3921: P. H. Skelton, I. G. Gaiger, J. Cambray, September 1976, Serfontein Bridge on Orange River.  
AM/P 7840: P. H. Skelton, J. Cambray, September 1980, Blouputs, lower Orange.











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